UNIVERSITY GEOLOGICAL SURVEY of KANSAS

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SPECIAL REPORT ON COAL.

BY
ERASMUS HAWORTH,
ASSISTED BY
W. R. CRANE.

VOL. III.

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FOR VOLUME III.

ERASMUS HAWORTH, Geologist.

W. R. CRANE, Assistant Geologist and Chemist.

Dr. F. H. Snow, Chancellor of the University of Kansas:

SIR—I have the honor to submit to you herewith a special report on Kansas Coals prepared by the Department of Physical Geology and Mineralogy of the University. This report will constitute Volume III of the reports of the University Geological Survey of Kansas.

Yours most respectfully,

ERASMUS HAWORTH.

DEPARTMENT OF PHYSICAL GEOLOGY AND MINERALOGY,
UNIVERSITY OF KANSAS, July 1, 1898.

PREFACE.

THE preparation of the following report on the Coals of Kansas has been done chiefly by the writer and Mr. W. R. CRANE, although in the true sense of the term almost all the investigations conducted in the Coal Measures of Kansas during the last five years have contributed directly or indirectly to the information herein expressed.

Such a report on the Coals of the state could not be made until the detailed stratigraphy was well worked out. A large part of our time has therefore been devoted to the detailed stratigraphy of the eastern part of the state. This was partly described in Volume I, published early in 1896. The following descriptions of the general stratigraphy of the Coal Measures are based necessarily on the similar descriptions in Volume I.

During the summer of 1897 the writer was again assisted by Dr. GEORGE I. ADAMS, by the Rev. JOHN BENNETT, and by Mr. W. E. RINGLE, all of whom devoted their entire time to stratigraphic work. Doctor Adams confined his labors to the Coal Measures in the southern part of the state, reaching north approximately to a line trending east and west through Fort Scott and Iola. Mr. Bennett traced in detail the outcroppings of the several limestone systems northward of this line and south of the Kansas river. Mr. Ringle assisted Doctor Adams.

After the field season closed Doctor Adams likewise was of great assistance in the drafting room in reducing the substance of his summer's work to drawings, in the preparation of geologic sections, geologic maps, etc. It was with regret on the part of

the writer that he did not prepare the manuscript in full for the stratigraphy of the part of the state covered by his field work, but at his own request he was excused from the same.

It is a matter of great satisfaction, and at the same time of no little surprise, to be able to state that the outlines of the stratigraphy of eastern Kansas, as given in Volume I, are substantially correct. The work for that volume was done hurriedly and the report was looked upon as a mere reconnaissance. We are now able to make a more detailed report, and one which may carry with it greater authority, on account of its being based upon more detailed and accurate field work. The only positive errors found in previous work are two: The Altamont limestone given in Volume I as the lower member of the Erie system is now known to be the eight-foot limestone mentioned by Bennett on page 94 of Volume I, and shown in Plate IV; and the Carlyle of Volume I, according to the conclusions reached by Mr. Bennett, is the same as the Garnett limestone. These two errors are of little importance excepting from the perturbations they cause in nomenclature. The name Altamont can be retained, as Bennett gave no name to the eight-foot system in his description, but either the name Carlyle or Garnett must be discontinued as they refer to the same article. On account of the name Garnett having been used so much more extensively than Carlyle the latter will be dropped, as explained in detail in the proper place in this report.

Mr. Crane's work in connection with this report has been confined principally to an investigation of the chemical and physical properties of the coals, and to a detailed study of mining machinery and mining methods. All the analyses and determinations of heating properties given in the following tables were made by him, excepting the small number which are properly credited to others. Likewise the pen and ink drawings used

in his part of the report to illustrate machinery and methods are all the work of his hand. The character of his work can be judged of by the readers. It may not be out of place, however, to add that the greater part of his analytical work was done wholly without any expense of any kind to the state, and that the remainder was done at such nominal expense that it is almost without a parallel in the history of public investigations of this kind for state purposes.

ERASMUS HAWORTH.

University of Kansas, Lawrence, July 1, 1898.

PART I.

STRATIGRAPHY OF THE KANSAS COAL MEASURES.

By ERASMUS HAWORTH.

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STRATIGRAPHY OF THE KANSAS COAL MEASURES.

THE stratigraphy of the Kansas Coal Measures has been partly described in many publications. Volume I of this Survey contains the longest connected description thus far published. That description was based principally upon field work done by this Survey, but was looked upon as being elementary in character. For that reason, and in order that the reader might the better judge of the correctness of conclusions subsequently drawn, a number of geologic sections trending mainly east and west were, in the early chapters of the discussion, described in detail by the parties making them. Field work in stratigraphy has been carried on to a considerable extent for each of the past five seasons. This has enabled us at present to give a tolerably detailed and connected description of the stratigraphy of the Kansas Coal Measures. While it will largely be a reproduction of that already published in Volume I it will also be a correction and confirmation of the same.

The Kansas Coal Measures rest on a floor of the Subcarboniferous limestone. This has been observed to be true throughout the whole of the eastern limit of the Coal Measures and has been proved to be true throughout all of the western part wherever wells have been drilled deep enough to penetrate the Coal Measures. The description of the Coal Measures proper may, therefore, begin with a description of the Subcarboniferous floor, after which the various subdivisions of the Coal Measures will be taken up in the order in which they are found in the ascending scale. While studying the descriptions of them the reader should refer constantly to the generalized section, Plate VI, and to the various other maps and sections illustrating them.

I.—The Mississippian or Subcarboniferous.

Areal Extent.

The area in Kansas covered by the Mississippian rocks is confined to the southeastern corner of the southeastern county. It is bounded on the south by the south line of the state; on the east by the east line of the state; and on the northwest by an irregular line trending northeast and southwest, crossing the south line of the state near Baxter Springs about six miles from the Missouri line, and the east line of the state about ten miles from the southeast corner, forming a triangle of about forty-five square miles, with the northwestern boundary approximately marked by Spring river.

In different places the western limit is carried beyond Spring river, particularly where tributaries enter from the northwest. These streams have worn their channels down through the overlying Coal Measures and have exposed the Mississippian for some distance further to the northwest. Along Cow creek, for example, the Mississippian rocks may be observed more than five miles above the general limit; along Shawnee creek they may be observed almost to opposite Crestline, three or four miles beyond the general boundary; along Brush creek the westward dentation is not so marked; while along Wall creek the western limit is two or three miles beyond the boundary. A few places are known beyond this limit where erosion has worn away the overlying Coal Measures exposing the Mississippian to the surface. This is particularly marked in what is now called Quaker Valley, to the northwest of the country postoffice Tehama. Here within five miles of the center of the county an area of several acres is covered principally with the Mississippian limestone and flint rocks, existing as an isolated outlying area, separated from the main body of the Mississippian by four or five miles.

Beyond the limits of Kansas the Mississippian occupies the surface over a large part of Missouri on the east, Arkansas on the southeast, and Indian Territory on the south. It forms, in Missouri, an irregular area extending east about thirty-five miles to beyond Springfield; to the northeast by way of Carthage, Stockton, Osceola, Sibley, Boonville, and Keatsville to beyond the Missouri river, from which point it veers eastward to the vicinity of Saint Louis, thence northwestward along the Mississippi river into Iowa. It occupies all of the northwestern part of Arkansas and the northeastern part of the Indian Territory, constituting a large area of well defined rocks of great thickness which must always be looked upon as one of the most important terranes of the great Mississippi Valley.

Surface of the Mississippian.

The surface of the Mississippian limestone in some places was greatly eroded during the pre-Coal Measure time. This has been commented upon by various geologists, has been illustrated by drawings and photographs by different authors, and varied and important conclusions have been drawn from such effects. The writer has already described[1] various irregularities of surface in southeastern Cherokee county, which are probably due to this surface erosion. The extent of such erosion farther to the northwest can only be conjectured, as the surface of the Mississippian soon becomes covered to a great depth with the overlying Coal Measures. The records of the various oil and gas wells in Kansas which have been carefully kept and accurately tabulated fail to show any marked irregularity of surface. This of itself is not conclusive, for the wells are not close enough together to disprove the existence of valleys of erosion in the surface of the Mississippian; however, with so many of them reaching the Mississippian limestones and at so nearly uniform and regular distances below the sur-

1. Haworth: "The Coal Fields of Cherokee County," Trans. Kas. Acad. Sci., vol. viii, pp. 7-11, Topeka, 1882; "A Contribution to the Geology of the Lead and Zinc Mining Districts of Cherokee County Kansas," p. 13, Oskaloosa, Ia., 1884; Kans. Univ. Quarterly, vol. ii, p. 126, Lawrence, 1891; Univ. Geol. Sur., vol. i, p. 147, Lawrence, 1896.
Hay: "Geological and Mineralogical Resources of Kansas," p. 5, Topeka, 1893.

face it is moderately certain no very great irregularity can exist on the upper surface of these limestones.

The importance of this question is connected principally with a study of shore lines during geologic time. The Mississippian rocks were formed under ocean water. Where the surfaces are eroded they were of course subsequently elevated above the ocean water and thereby the ocean shores receded to the west. Later, when the Coal Measures were laid down, covering eroded surfaces, the shore lines again migrated eastward. If, during the erosion period, the shore line migrated very far to the west the eroded area likewise will extend farther west. But if, on the other hand, the eroded area forms a narrow stretch extending along the southeastern limit of the Coal Measures as we now find them, then the shore line immediately previous to Coal Measure time did not progress very far to the west. This latter condition seems to have prevailed.

The extent of erosion in Kansas, as far as is known, is not very great, and therefore does not imply a very long period between Subcarboniferous and Coal Measure time. There is a perfect conformity between the Coal Measure strata and the upper surface of the Mississippian in Kansas when viewed over wide areas, as is clearly shown by the geologic sections published in Volume I, and those which accompany this report. If, therefore, there were any considerable oscillations after the Mississippian limestones were formed and previous to Coal Measure time it is remarkable that the final state of equilibrium reached and maintained during the earlier part of Coal Measure time should place the surface of the Mississippian in a position so that no broad nonconformities should be produced. These conditions indicate, therefore, that the oscillations which resulted in leaving the Mississippian rocks above the sea and in again depressing them so they could be covered by Coal Measure strata were confined to slight vertical movements and to narrow limits along the coastal area, movements which did not materially affect the same rocks further oceanward.

Inclination of Surface.—The upper surface of the Mississippian floor dips to the west and northwest. Along the southern line of the state from Galena to Coffeyville the maximum dip is not known, as no well at Coffeyville has thus far reached the Mississippian. Wells have been drilled from 550 to 600 feet and have not reached it. As the elevation of Coffeyville is 728 feet above sea level and the hill tops at Galena something over 1,000 feet and the distance between the two points fifty-three miles, we know that the inclination westward is at least 17 feet to the mile. By an examination of the geologic section from Galena westward by way of Cherryvale, Plate I, it will be seen that we have the surface of the Mississippian at Oswego about 400 feet above sea level, which would give the inclination from Galena to Oswego at about 20 feet to the mile. Wells at Stover and Mound Valley do not reach the Mississippian, but at Cherryvale, fifty miles away, it was reached at 1,008 feet below the surface, or 180 feet below sea level, which gives the decline of the surface from the hill tops at Galena at about 22 feet to the mile, or but a little over 20 feet to the mile if reckoned from the valleys about Galena. The deep well at Neodesha shows substantially the same results. The deep wells farther west in the vicinity of Fall river, Fredonia, Wichita, and other places throw little light on the subject as they do not reach the Mississippian, but their great depth without reaching it shows that it must occupy a position similar to that indicated from the dip further east.

In a direction northwest from Galena the inclination of the surface of the Mississippian is not so great. A well made with a diamond drill, producing a core, at Saint Paul—Osage Mission—thirty-nine miles northwest from Galena, went to a depth of 700 feet without reaching the Mississippian. The elevation of Saint Paul above sea level is 873 feet, showing that the Mississippian is at least within 173 feet of sea level and that its surface has a dip from Galena of not less than 21 feet to the mile. At Chanute, fifty-eight miles away, it was reached 36 feet below sea level, and at a few other points in that vicinity at similar

depths. The decline from Galena to Chanute towards the northwest is therefore between 17 and 18 feet to the mile.

Northward, along the east line of Kansas, the inclination is much less. The Mississippian is reached at Girard at 493 feet above the sea level, at Fort Scott at 385, at Pleasanton at 206 feet above sea level, and at Kansas City at sea level. The inclination from Galena to Girard therefore is about 16 feet to the mile; from Galena to Fort Scott between 11 and 12 feet to the mile; the inclination from Galena to Pleasanton between 10 and 11 feet to the mile; and from Galena to Kansas City between 7 and 8 feet to the mile. The direction from Galena to Kansas City, by way of Girard, Fort Scott, and Pleasanton, makes a sharp angle with the line of the southeastern limit of the Coal Measures or the northwestern margin of the Mississippian area.

Lines in a direction more nearly at right angles with this northeastern and southwestern trend would probably show a greater dip to the apparent surface of the Mississippian. East of Fort Scott the Mississippian is reached about twelve miles beyond Nevada, Mo., or thirty-one miles from Fort Scott. Along this line the upper surface of the Mississippian dips westward between 14 and 15 feet to the mile. Fifty-four miles eastward from Pleasanton the Mississippian comes to the surface a little beyond Brownington, at an elevation of about 760 feet above sea level, which gives a dip of between 10 and 11 feet to the mile. Sixty-three miles to the southeast of Kansas City the Mississippian appears at the surface in the vicinity of Sweet Springs, which would give it an inclination towards Kansas City of about 15 feet to the mile. Westward from Kansas City it has not been reached in any of the deep wells. The well at Topeka reached a depth of over 1,600 feet, which shows that the Mississippian inclines not less than fourteen feet to the mile for that distance. The McFarland well, of over 2,000 feet, likewise shows that the inclination must be as great as 13 feet to the mile to that point.

We may conclude, therefore, from the above data, that along the southern line of Kansas the Mississippian floor declines

more rapidly to the west than in any other direction, where it has an inclination of more than 20 feet to the mile; that to the northwest from Galena, by way of Saint Paul and Chanute, the inclination is considerable less, reaching but 17 feet; and that the westward inclination from other points further north is less than the westward inclination from Galena. These conclusions are important and are in accord with the detailed stratigraphy of the Coal Measures which overlie them, all of which show that there was an extraordinary thickening of deposits along the southern line of Kansas which thinned both eastward and northward to near the middle line of the state, and which again thickened northward. There seems to be a slight ridge in the Mississippian floor trending east and west and passing through the middle part of the state, probably by way of Pleasanton, and reaching to an unknown distance to the west.

II.—The Coal Measures.

The Coal Measures proper of Kansas constitute a heavy mass of rocks aggregating almost 3,000 feet in thickness, composed of alternating beds of limestones, sandstones, and shales. In general character the limestones have a strong resemblance from the lowest to the highest, with sufficient differences in detail to make a discrimination between them possible by a minute examination. The lower and older limestones are a little more dense in appearance, finer in texture, and are more highly crystalline than those higher up in the geologic scale. Their color is a stronger, richer, bluish brown and buff, and in general appearance they are more substantial, and apparently will resist decay more strongly. The higher and younger ones are lighter in color, approaching a delicate light buff, sometimes even an almost pure white, and have an inferior, younger, and more delicate and friable appearance.

The shales likewise are similar in general character from top to bottom of the Coal Measures. In detail there are certain differences, which may be noticed by the experienced eye, sufficiently marked to enable one to discriminate in a general way between the older and the younger, yet these differences are such that they can hardly be described. We find black shales at the base of the Coal Measures and near the top; we find light colored shales at the base of the Coal Measures and near the top; we find greenish colored shales at the base of the Coal Measures and near the top, with all other varieties recurring irregularly at intermediate positions. Apparently it is impossible to decide that this shale is an old shale because it is black or any other color, or that the other shale is a young shale for similar reasons. The Cherokee shales lying at the base of the Coal Measures have beds jet black in color, but likewise shales equally black may be found here and there in the Upper Coal Measures. They have beds a pale ashen gray in color which are duplicated in almost every detail in the Upper

Coal Measures. In general the younger shales, particularly near the top of the Coal Measures, are a little more inclined to a reddish hue, with streaks of clay shale here and there decidedly red in color. Greenish tinges are also more common in the younger shales than in the older. The names of the colors found at one place may be practically the same as those at the other, the principal differences being in the particular run of degrees of greens or browns or grays, with different degrees of intensity of these same runs of color.

In texture the same conditions prevail. The older shales contain clay shales free from sand, and also argillaceous shales which gradually grade over into sandstone. Likewise the shales of middle age and of younger ages have beds of clay shales within them, and of arenaceous shales which grade into sandstones, in every respect similar to those of greater age. It is only by regarding a few details, therefore, that one may be able to recognize the differences between various shale beds as regards age.

With the sandstones there is perhaps a greater difference than with either the limestones or shales. The Lower Coal Measure sandstones are more firmly cemented and produce much more valuable building stone than any sandstones yet discovered in the Upper Coal Measures. Aside from this fact but little difference can be noted regarding the geologic age of the sandstone in question.

CHEROKEE SHALES.[2]

At the base of the Coal Measures lies a heavy bed of shale, averaging from 400 to 500 feet in thickness, which here and there carries a considerable amount of sandstone. This shale bed is the heaviest and the most extensive of any one constituting a part of the Kansas Coal Measures.

Areal Extent of the Cherokee Shales.

The Cherokee shales cover the surface of the greater part of Cherokee county, and the southeastern corners of both Craw-

2. Haworth and Kirk, Kansas University Quarterly, vol. ii, p. 105, Lawrence, 1894.

ford and Labette counties, representing an area approximately 540 square miles in Cherokee county, 200 square miles in Crawford county, and 100 square miles in Labette county. In addition, at different places in southeastern Bourbon county streams have cut through the overlying formations and exposed narrow strips of Cherokee shales aggregating at least twenty-five square miles.

Beyond the limits of the state on the south the Cherokee shales are known to cover a wide area in the Indian Territory and quite probably bear eastward and across into Arkansas, south of the Boston mountains, forming the principal coal fields of that state. This, however, has not been fully demonstrated. To the northeast of Kansas they pass into Missouri. The writer has traced them across the northeastern part of Jasper county and into Barton county. There are many reasons for believing the same general shale beds, with probably slight variations in character, extend far into Missouri and possibly even across into Iowa, constituting a part of the Lower Coal Measures of the Des Moines formation of that state. While this has never been established by complete mapping in the field, yet the heavy shale beds at the bottom of the Coal Measures of Missouri and Iowa seem to be continuous with the Lower Coal Measure shales of Vernon and Barton counties, Missouri, and if so then they are continuous with the Cherokee shales of Kansas.

The westward extension of the Cherokee shales is great. This is conclusively shown from the records of the various oil and gas wells drilled in the southeastern part of the state. Every one of them, if carried deep enough, strikes the Cherokee shales and shows something of their thickness. The Toronto well is about seventy-five miles west of the eastern side of Kansas, or a hundred miles west from the easternmost extension of the Cherokee shales. This well penetrated the shales about 372 feet, showing that their thickness is maintained westward to a remarkable degree. Likewise wells at Fall River, Howard, and other western points reveal the same general conditions. With this positive evidence before us it may well be assumed that the Cherokee shales extend westward at least a

hundred miles further before they are very seriously altered in general character. Deep wells now in operation beyond the Flint Hills, in the vicinity of Wichita, Hutchinson, etc., if carried to a sufficient depth, doubtless would find the same bed of shales.

Thickness of the Cherokee Shales.

In thickness the Cherokee shales have the following measurements: At Oswego, 500 feet; at Cherryvale, 425 feet; at Neodesha, 425 feet; at Saint Paul, 416 feet, with an undetermined remainder at the bottom of the well; at Chanute, 410 feet; at Girard, 446 feet; at Fort Scott, 410 feet; at Pleasanton, 440 feet; at Kansas City, 420 feet; at Leavenworth, 540 feet. Further west few wells have passed through them. The Topeka well implies that the Cherokee shales have a much greater thickness at that place, apparently being 700 feet with an undetermined amount below the bottom of the well. At McFarland the well seems to have struck the Cherokee shales at a depth of 1,832 feet and continued in them to 2,006 feet, at which point drilling was discontinued. At Toronto the well seems to have reached the Cherokee shales at a depth of about 1,000 feet and passed into them 350 feet to the bottom of the well, leaving an undetermined remainder below. What their thickness is further west is wholly conjectural as no well has thus far been drilled into them of which a record has been kept.

Various wells have been drilled to the northeast of Leavenworth at different points in Missouri, the records of some of which are on file in the office of this Survey. Such wells show conclusively that the general thickness of the Cherokee shales is maintained to the northeast for a considerable distance beyond the limits of Kansas.

General Characteristics of Cherokee Shales.

The character of the Cherokee shales varies materially both vertically and longitudinally. Shale of almost all descriptions may be found. With reference to color, portions of them are as black as coal and at a short distance cannot be distinguished from coal. These carbonaceous shales are abundant in various

places. At the immediate summit of the shales, just underlying the Oswego limestone, such a bed is found from ten to twenty feet in thickness. It is in this black carbonaceous shale that the Fort Scott coal occurs. Likewise at other points lower down prominent beds of jet black carbonaceous shale are found which so strongly resemble coal in color that numerous instances are known of people who were badly disappointed in not being able to use such masses for fuel.

From this extreme many variations may be noted through different degrees of black and gray and greenish gray into a very light colored ashen gray shale. Sometimes, too, such a light colored shale is close to the heaviest coal beds. An instance of this is at the Nesch brick factory at Pittsburg. Here the shale which overlies the coal is used for brick making. In color it is a light leaden gray, although taken from but a few feet above the heaviest bed of the Pittsburg coal. As far as observed the Cherokee shales furnish no example of a red color, and therefore do not thus imply a concentrated ocean water.

Sandstone in the Cherokee Shales.—A careful study of the Cherokee shales with reference to their composition likewise shows a great variation, ranging from a fairly good clay shale, composed almost entirely of clay, into a perfect sandstone, with all intervening grades. The records of every well studied show that a relatively large proportion of arenaceous shale and sandstone is found. Where they come to the surface the sandstone is irregular in position. At the base of the shales a mass of sandstone is found along the west bank of Spring river which in places is from 20 to 30 feet thick. This is noticeable from south of Baxter Springs far into Missouri on the northeast. Frequently the sandstones are highly indurated, producing a firm and solid rock, the boulders from which are prominent. A few hundred yards northwest from the border, sandstone may or may not be found. In the vicinity of Lowell station, on the Kansas City, Fort Scott and Memphis railway, and northeast, just outside the timber line along Spring river, many wells were examined which showed a great variation in the character of the

material they passed through. Some of them found sandstone extending down to the surface of the Mississippian limestone, while others found shale resting directly on the Mississippian. The deep wells show a similar variation; some of them find sandstone lying immediately at the base of the shales, and others do not.

The amount and position of the sandstone beds throughout the Cherokee shales justify the conclusion that at no time were the conditions favorable for the production of a large and continuous sandstone area. In Cherokee county the most noted sand rocks are those capping the hills in the vicinity of Tehama postoffice, the Columbus sandstone,[3] a mass of rock which lies about 150 feet above the base of the shales, and which are exposed for miles to the northeast and southwest, passing near Crestline, Tehama, Neutral, and Baxter Springs. Wherever the cementing material has been extraordinarily abundant, producing an unusually firm rock, hills and escarpments result from the protection afforded by such sandstone. Generally but a short distance on either side the absence of escarpments shows plainly that the sandstone was less durable and therefore more easily eroded. Likewise observations made in the coal mining districts from near Columbus northeast to Arcadia reveal the same general variations. Here the coal is covered by a firm arenaceous shale which might almost be called a sand rock, producing a firm and durable roof so desirable in coal mining; there, possibly less than a mile away, the arenaceous character of the shale has disappeared and the roof is "rotten," and the mine dangerous from caving; while beyond, the same conditions recur in stencil-like repetitions.

Coal in the Cherokee Shales.— The Cherokee shales carry the largest beds of coal known in Kansas, the Weir-Pittsburg coal. A coal of but little importance lies immediately at the base of the shales which is found here and there in the southeastern part of Cherokee county. It has never been mined to any extent, except locally in a few instances more than twenty years ago.

3. **Haworth and Kirk: Kansas University Quarterly, vol. ii, p. 106, Lawrence, January, 1894.**

Above this and immediately under the Columbus sandstone a bed of coal occurs with a thickness varying from twelve to eighteen inches. This coal has been mined by the strip pit process at scores of places to the northeast, east, and southeast of Columbus. It is fair in quality and is easily mined. It outcrops along the sinuous line of the Columbus sandstone escarpment. During recent years, since the price of coal has become so low, it has not been found profitable in that part of the state to operate so thin a bed of coal, but during the coal miners' strike in 1893 many little mines sprang into existence along the outcropping of this bed which furnished a good supply of coal for neighboring towns and rural districts, thereby preventing any serious lack of fuel throughout the strike period. This Columbus coal lies at about 150 feet above the base of the Cherokee shales, but westward and northwestward it either disappears or occupies a lower position. The record of the Weir City water well shows that at 64 feet above the base of the shales a 2-foot bed of coal appears, with another 14-inch bed 168 feet above the base. It is impossible to say which one of these two coals corresponds to the Columbus coal, if either.

Above the Columbus coal the next coal of importance found at the surface is the Weir-Pittsburg heavy bed, that averages nearly 40 inches in thickness, and which lies about 250 feet above the base of the shales. Still above the Weir-Pittsburg lower bed is the so-called "upper" bed that will average about 27 to 30 inches in thickness. Westward from the outcropping of these two still other small beds of coal are found and are mined at various places.

At the very summit of the Cherokee shales we find the Fort Scott coal lying but a few feet beneath the Oswego limestone. It averages from 15 to 20 inches in thickness, and has been mined extensively by stripping at many places in the vicinity of Fort Scott. The Oswego limestones have produced greater or lesser escarpments with numerous indentations made by drainage channels, producing an exceedingly sinuous outline. The coal mining has been confined to a strip of from 10 to 50 feet in width, following these outlines.

The northwestern extension of these various coal beds is a matter of great economic and scientific interest. How wide was the coal forming zone? And how much of that zone yet remains intact from erosion? Those interested in the question financially have devoted considerable time and money to prospecting to the west and northwest from Weir City and Pittsburg. It seems that the northwestern limit of the heavy Pittsburg coal is only a few miles away, and that the workable coal forms an irregular, elliptical area trending northeast and southwest, and is a little less than ten miles in width. The other coal beds likewise have a limited westward extension. It is probable that they formerly reached farther to the southeast and have been destroyed by erosion.

But the Cherokee shales as a whole contain large quantities of coal. Almost every deep well throughout the southeast part of the state shows a considerable quantity of coal, which, if combined in one horizon, would be exceedingly rich. The furthest western workable deposit thus far known is at Leavenworth, seventy-five miles to the northwest from the Mississippian exposures. Here at a depth of 720 feet a 2-foot bed of coal is found which is about 100 feet below the top of the Cherokee shales. Above it, 28 and 42 feet respectively, are two other beds of coal, 6 inches and 12 inches each, while below, at a depth of 747 feet and at 988 feet, are two beds of coal each of which is 2 feet in thickness, aggregating 7 feet 6 inches of coal in the Cherokee shales at Leavenworth.

Whether the same amount of coal could be found at other points equally distant from the eastern limits is not known, but there are no geologic reasons for doubting it. Such a line would pass from Leavenworth through Lawrence, Ottawa, Burlington, Yates Center, Fredonia, and Sedan, forming an area aggregating over 12,000 square miles, under any portion of which coal is liable to be found in as great abundance as at Leavenworth. The drill records, however, show that in many places it does not occur in such great abundance. The wells at Girard and Fort Scott and other places near by the heavy coal beds show that these particular coal beds do not extend very

far to the northwest. But all of them show that coal forming conditions obtained to a great extent throughout the whole period of formation of the Cherokee shales. The well at Oswego, for example, passed through eleven distinct beds of coal, and the one at Cherryvale passed through nearly as many, with a 27-inch bed within ten feet of the bottom of the shales. Whether future prospecting will develop other deeply buried coal beds as valuable as the Leavenworth ones are no one can tell in advance, but from every consideration of the geologic conditions there is no reason to doubt the occurrence of similar and equally valuable deposits. It is tolerably well established that the Cherokee shales, over the above-mentioned area of 12,000 square miles, will average nearly one per cent. of its aggregate thickness in coal.

Limestone in the Cherokee Shales.—Here and there throughout the extent of the Cherokee shales varying amounts of calcareous matter appear. In some places a limestone of considerable importance is found, such as the one just west of Cherokee, a limestone reaching 4 or 5 feet in thickness and covering many square miles in area. Elsewhere a finer and more impure bed of calcareous matter may be found from 6 inches to 24 inches in thickness. Sometimes concretionary masses, largely calcareous in character, are abundant, producing odd shaped forms round or irregular and varied as concretionary masses usually are. They are occasionally found at many places within the Cherokee shales but most abundantly at the upper part, immediately over and under the Fort Scott coal.

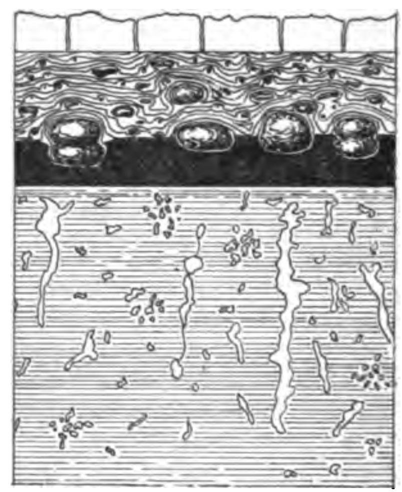


FIGURE 1.
Section at Fort Scott showing Calcareous Concretions in the Shale Adjacent to the Fort Scott Coal. (After Bennett's Fig. 4, Vol. I.)

Some of them are semi-spherical in shape, reaching diameters of 15 or 20 inches; others are exceedingly irregular, elongated vertically, and producing most peculiar forms. Figure 1 is a diagrammatic illustration of them. Frequently these lesser bodies are so intermingled with shale material that they are dark in color, and would yield upon analysis perhaps not more than 50 per cent. of calcium carbonate. The heavier beds of limestone, as the one near Cherokee already referred to, are good grades of limestone and frequently are well filled with remains of marine invertebrates. It is difficult to estimate the total amount of such calcareous material in the Cherokee shales, but it might not be far amiss to put the aggregate at from 5 to 10 feet in thickness.

Origin of the Cherokee Shales.

From the descriptions already given it is evident to the geologist that the Cherokee shales were, in the main, coastal deposits. The various sandstone horizons and the arenaceous shales with wave marks and ripple marks so abundant within them admit of no other explanation. The extensive accumulations of carbonaceous material in the greater and lesser coal beds likewise show that the shales were formed near shore and probably in shallow water. The thin beds of limestone and other calcareous material which are so frequently found imply that the water under which the shales accumulated was ocean water. Another evidence of the latter is the frequent occurrence of salt water obtained from the Cherokee shales in many drilled wells. Some of the drillers even report finding beds of rock salt. Whether the latter is true or not it is abundantly demonstrated that the Cherokee shales produce vast quantities of salt water, the salt from which came originally from ocean water.

Attempts were made to locate the heaviest and most extensive sandstone beds to throw light upon the question of coastal boundaries during the period of the deposition of the Cherokee shales. The irregular occurrences of the sandstone made such a task difficult. In general there are indications that the coastal lines extended far to the southwest, and that the conditions favor-

able for sandstone production were more prominent than farther north. Yet it must be confessed that the heavy gas-bearing sandstones in the vicinity of La Harpe and Iola militate against these views. The great variation of materials and lack of continuity in the sandstone beds imply a large number of small streams carrying sand from the dry land areas into the western ocean and the rapid deposition of the Cherokee shales, rather than a smaller number of streams and a slow deposition thereby permitting the ocean waves more nearly to equalize the strata by long continued wave movements. The sandstones and coal at the very base of the Cherokee shales at Cherryvale imply as strongly a coastal origin as do the sandstones and coals at the base of the shales fifty miles further east. Could we reproduce the scenes of those carboniferous times they would represent low coastal plains over which the tidal waves were carried and to which the land drainage was continually adding sediment, while the luxuriant growth of coal-forming plants was producing material for coal.

OSWEGO LIMESTONES.[4]

Immediately above the Cherokee shales lie two distinct beds of limestone separated from each other by an unusually black shale varying from 4 to 12 feet in thickness, being in most places about 7 or 8 feet. This places the two limestone beds so close together that they practically have the same southeastern extension and may be considered as one limestone system. In his report on Kansas Geology of 1866 Professor Swallow named the lower one Fort Scott Cement Rock, and the upper one Fort Scott Limestone. In 1894, on account of the intimate association of the two limestone horizons Haworth and Kirk suggested that they might be grouped into one system and offerred the name Oswego limestones for the group.

Areal Extent of the Oswego Limestones.

The Oswego limestones outcrop to the southeast along an exceedingly irregular line crossing the south side of the state about

4. Haworth and Kirk: Kansas University Quarterly, vol. ii, p. 105, Lawrence, January, 1894.

five miles west of the southeast corner of Labette county. From here the line of outcropping passes to the north always following up stream along each drainage line, no matter how small, and is found in the Neosho river bluffs at Oswego. They occupy the high bluffs on the west bank of the river almost as far north as Laneville, from which place they cross over to the south, forming a line of bluffs on the west side of Lightning creek to beyond the north line of Cherokee county. At a few places northeast of Sherman the limestones are still left on outlying mounds and high bluffs on the east side of Lightning creek. They finally cross to the east side of Lightning creek in the southern part of Crawford county, reach southward at a point or two into Cherokee county, then veer again to the northeast passing about three miles east of Girard and finally almost reach the state line at Mulberry, from which point they again veer to the northwest on the western side of Drywood, and thence north to about three miles of Fort Scott, from which place they extend eastward into Missouri.

The Oswego limestones do not cover the surface of a very wide area of territory, but soon pass beneath the overlying strata to the west. The deep well records at various places in the state show that they are continuous westward and northwestward for many miles. The wells at Mound Valley, Cherryvale, Independence, La Harpe, Iola, Toronto, and many others all give the same evidence. An inspection of the geologic sections, Plates I and II, illustrates this better than can be told by words. Their thickness gradully increases westward. At Cherryvale they probably represent 30 or 40 feet of limestone, but are everywhere separated by a thin bed of shale corresponding to the one observable along their outcroppings.

Fort Scott Cement Rock.

The lower member of the Oswego system is the limestone from which the Fort Scott hydraulic cement is manufactured. It consists in most places of but one layer, being in appearance of a light lead-gray color, forming a compact and fine grained texture, with a conchoidal fracture. Whether it retains these

qualities far to the west cannot now be determined, as the cuttings from the drill do not show its characters in detail.

The chemical composition of the cement rock is interesting. A few published analyses may be found here and there, made years ago, with the authority for the analyses rarely given. Recently this Survey has had a number of analyses made from specimens very carefully chosen and located by Mr. Bennett, with the results as given in the table on opposite page.

No. 4 is a sample which Mr. Thomas, superintendent of one of the cement works, calls the best cement rock in the district. The other samples are all taken from the quarries furnishing material for the cement factories.

A few points of special interest in the composition of the rock as above given may be mentioned. First, the comparatively low per cent. of magnesium carbonate in the rocks at the factory north of the city as compared with those taken from the city limits. The average of the five analyses made from the northern rock is but 5.36, while the average of the six analyses made from rocks gathered within the city limits is 15.86. This difference in the amount of magnesium carbonate the limestone contains with the specimens gathered less than three miles apart is quite unusual. But the most surprising feature of the whole composition is the variation of the amount of magnesia in the vertical range. For example, sample "1 a" from the top of the layer has but 2.26 magnesium carbonate while "1 b" from the middle of the layer has 12.21, and "1 c" from the bottom has 20.92, although the rock here is not over 5 feet in thickness. Samples "2 a," "2 b" and "2 c" show a similar condition. Sample "2 a" is taken from the top of the layer, "2 b" from the middle, and "2 c" from the bottom, with amounts respectively, 17.33, 26.62, and 15.88. Why we should find this great difference in the amount of magnesium carbonate is difficult to explain, and particularly so as the largest amount in "2" and "3" is in the middle of the layer where the weathering agents and the metamorphic agents of any description have had no influence whatever as far as can be judged from the appearance of the rock. Usually it is considered that

TABLE I.—ANALYSES OF FORT SCOTT CEMENT ROCKS.

Cement Rock from		Calcium Carbonate $CaCO_3$	Magnesium Carbonate $MgCO_3$	Silica SiO_2	Silica and Insoluble	Ferric Oxide Fe_2O_3	Alumina Al_2O_3	Ferric Oxide and Alumina	Potash and Soda, K_2O, and Na_2O	Water H_2O	Undetermined	Water and Undetermined	Totals	Analyst or Authority
Fort Scott, Kan.	No. 1a.	73.95	2.26	18.75	......	2.32	2.15	......	......	0.37	0.20	......	100.00	Dr. Edward Bartow.
	No. 1b.	63.05	12.21	16.64	......	4.43	3.09	......	......	0.26	0.32	......	100.00	
	No. 1c.	55.40	20.92	13.34	......	6.57	1.51	......	......	0.29	1.97	......	100.00	
	No. 2a.	60.21	17.30	15.48	......	2.98	2.71	......	......	0.31	1.01	......	100.00	
	No. 2b.	53.16	26.62	11.75	......	4.59	2.06	......	......	0.33	1.49	......	100.00	
	No. 2c.	51.12	15.88	24.25	......	5.04	2.28	......	......	0.63	0.80	......	100.00	
	No. 3a.	65.62	4.43	18.45	......	2.17	8.47	......	......	0.44	0.42	......	100.00	
	No. 3b.	64.93	11.01	16.27	......	3.87	2.91	......	......	......	1.01	......	100.00	
	No. 3c.	54.80	4.77	32.07	......	3.40	3.99	......	......	......	0.97	......	100.00	
	No. 4.	77.90	3.27	13.84	......	1.68	2.47	......	......	......	0.84	......	100.00	
	No. 5.	81.34	3.32	11.08	......	1.69	1.77	......	......	......	0.80	......	100.00	
	——	65.21	10.65	......	15.21	......	4.56	......	......	......	4.37	......	100.00	Mineral Industry, Vol. I.
Rosendale, Ulster Co., N.Y.		45.91	26.14	......	15.37	......	......	11.38	......	......	......	1.20	100.00	
Utica, Ill.		42.25	31.98	......	21.12	......	......	1.12	......	1.07	2.46	......	100.00	
Milwaukee, Wis.		45.54	32.46	......	17.56	3.03	1.41	......	......	......	......	......	100.00	
Cement, Georgia		43.50	22.00	......	22.10	1.80	5.45	......	0.22	4.95	......	......	100.02	
Siegfried, Pa.		78.92	2.66	......	11.62	......	......	6.25	......	......	0.55	......	100.00	

a. Samples taken from top of layer. b. Samples from middle of layer. c. Samples from bottom of layer. Rock No. 1 is from the southeastern part of the city. No. 2 is from northeast part of city. No. 3 is from the cement factory north of the city. No. 4 is rock considered the best. No. 5 is rock said to contain too much lime.

the high per cent. of magnesium carbonate in limestones is at least partially due to a process of dolomization. But here we have the middle part of the limestone carrying by far the largest amount of magnesia and at the same time showing no indication whatever of having been dolomized to any appreciable extent. It would seem that the magnesium carbonate is an original constituent of the rock mass, yet one cannot well make such a statement unconditionally.

Beyond the Fort Scott district no hydraulic cement has been made from this rock, excepting, perhaps, a few trial quantities at Oswego and elsewhere. Neither have analyses of the rock been made. From general appearances, however, one might think that the properties of the limestone were equally favorable for cement either north or south of Fort Scott.

Fort Scott, or Upper Oswego Limestone.

The Upper Oswego or Fort Scott limestone differs in many particulars from the lower one. It is co-extensive with it wherever observed, and, being above, is more frequently exposed to the surface than the Lower or Cement rock. The occurrence of the two in the vicinity of Fort Scott has been sketched by Bennett, and the following quotation is from his description:[5]

"Immediately above this interesting shale bed [Cherokee shales] lies the first important limestone of our section. It consists of a single stratum which is 4½ feet thick, the vertical seams in which cut it into large blocks. These blocks are flat at their base, although they do not lie directly on the shales, for a few inches of argillaceous limestone comes between. This little seam grades from a pure buff clay to a firm rock structure, the firmer portions on some little exposure being easily split into very thin horizontal sections. The upper portions of the rocks are rounded, giving the surface, where some time exposed, a rough appearance. Where recently exposed this rough surface is leveled up by hard calciferous clays, the effect of which is to take away the rough appearance of the upper surface. The local name given to the limestone is the 'cement rock,' from the fact that the Fort Scott hydraulic cement is made from it. At the cement mill, north of the Marmaton, on the Kansas City, Springfield & Memphis railway, it is quarried extensively and burned by the underlying coal. On long exposure the limestone breaks into angular fragments of all dimensions, and it weathers buff, although originally of a light gray color. It is noted for its large crinoid remains—the calcareous columns of these plant-like animals reaching a diame-

5. University Geological Survey of Kansas, vol. i, pp. 89-90, Lawrence, 1896.

ter of 1¼ inches. They occur all the way through it, but more frequently in the clays immediately below. Exceedingly large varieties of *Meekella striato-costata*, *Productus punctatus*, *Athyris subtilita*, and other organic remains are to be found in it. A coral mentioned in the system of limestones above this has an existence here, *(Chætetes milliporaceous)*, also another coral, *Syringopora*.

"Between the 'cement' limestone and the system immediately associated with it above, is a stratum of clay and bituminous shales. The latter form the greater part, and at their middle lies a thin coal vein, nowhere over an inch thick along the Marmaton where seen, and frequently in the same region altogether wanting. At the summit of this shale is a yellow clay streak varying from 4 inches to a foot which yields a minute form of the characteristic coal fossil *Chonotes mesoloba*, also many of the dorsal valves of *Spirifer plano-convexus*. The concretions found so abundant, in the bituminous shales below, are found in like quantities and peculiar forms, in these shales above.

"In our upward course we have now reached one of the most remarkable limestones in our whole series. It runs from 10 to 14 feet in thickness. The lower layers are somewhat evenly bedded, with frequent vertical seams, making it easily quarried. This part of it is fairly good building stone, as can be seen in many houses made of it in Fort Scott and the neighboring country. The upper section of it, however, is unevenly bedded, and tells the story of its origin, so full of interest to the paleontologist. It takes him far back into the dim and misty past, when innumerable polyp life built up their stony abodes, and left a coral reef for the citizens of Fort Scott to erect their homes upon. Vast quantities of this coral has been crystallized until scarcely a trace has been left of its original condition, but much of it is yet found with its cells as plainly visible as on the day the coral builder put his filmy parting in the honeycombed apartments which he builded so well. In geology his house is known by the name of *Chætetes milliporaceous*.[6] Everywhere skirting the hills of eastern Bourbon county this rock is to be found, and in Crawford county to the south are numerous and interesting exposures of it with its abundance of *Chætetes milliporaceous*. This limestone extends east of Fort Scott into Missouri, and to the west is seen for the last time near the bed of the Marmaton three miles west and two miles south of the city. The Fort Scott, Springfield & Memphis railway rests upon it from Fort Scott to Fulton, a distance of 13 miles. . . . Its general dip, like all the rocks of the country, is to the northwest, but locally its position is quite horizontal. Sometimes it even rises towards the west and again dips very rapidly, forming anticlinals and corresponding synclinals.

"There are good exposures of this interesting rock at the military bridge, one mile east and one mile north of Fort Scott, and at the Missouri Pacific cut near the plaza in Fort Scott, where the whole series from 15 feet below the 'rusty coal' up to this rock is exposed, as partly shown in Figure 1; again on the west side of the city by the cutting for the Minden branch of the Missouri Pacific railway, and again on the Missouri, Kansas & Texas railway to the southwest of the city three miles.

"In the lower section of this limestone the abounding and characteristic fossil

6. According to Zittel, this is not a coral, but a mollusk of the order Bryozoa.

is the *Spirifera martinia*, specimens of which can scarcely ever be taken out of their firm matrix in good condition. The coral so abundant in this system is nevertheless found in great quantities in the next limestone above, at its very summit, but it has not the lateral extent, as far as observed, which it has in this one."

LABETTE SHALES.[7]

First above the Oswego limestones is a bed of shale varying from 30 to 60 feet in thickness for which the name Labette shales is adopted. They are exposed along an irregular line from the south side of the state to the east side north of Fort Scott and constitute the whole of an escarpment here and there visible throughout the whole distance, the upper limits being the succeeding limestone which helps to produce the escarpment.

At Fort Scott they are 35 feet thick; at Labette City they are fully 60 feet. Southward they decrease in thickness until at the state line one can hardly notice them. Westward the deep wells show that they likewise decrease in thickness. The section at Fort Scott gives them less than 30 feet thick; the one at Cherryvale about 30 feet, where they carry a thin seam of coal; at La Harpe, Iola, and Toronto they are hardly visible, the overlying limestone going down and almost coalescing with the Oswego limestone below.

They have been so well described in the vicinity of Fort Scott by Bennett that we will again copy from his publication:[8]

"Over this limestone is a heavy bed of arenaceous and somewhat micaceous shales, varying from 35 to 60 feet in thickness. At the state line it is 60½ feet thick, at Fort Scott but 39, and at Rock school house, four miles southwest of Fort Scott, it is 80 feet thick, made so probably by the rapid dip of the limestone immediately below. The dip to the west here is 25 feet in 1,500 feet.

"Near the base of this shale bed and at its summit are everywhere to be seen two bituminous layers, the lower one yielding some coal in one place southwest of Fort Scott, where it is mined by stripping. Here it is an intensely black coal and lies in a bed of blue clay shale, not a particle of bituminous shale being in connection with it. This was a feature nowhere else seen in the coal deposits of Bourbon county.

"Dividing this whole area of shale into nearly three equal parts there are again two other streaks of bituminous deposits, which, in a few places, yield small quantities of coal. One of these coals, the upper, is capped by a calciferous clay quite cemented in places, and largely made up of broken shells and crinoids. There are many fossils in it unbroken, but so covered and cemented

7. Suggested by Dr. George I. Adams.
8. University Geological Survey of Kansas, vol. i, p. 91, Lawrence, 1896.

in the clays that clean specimens cannot well be secured from it. The prevailing types are *Derbyi* (hemipronites) *crassus; Chonetes mesoloba;* (in abundance) *Athyris subtilita; Lophophyllum proliferum; Campophyllum torquium; Zeacrinus*, and a small gasteropod.

"Near the top of this shale at the Missouri state line, but 16 feet from the limestone above, is found 2 or 3 feet of gray limestone in thin layers from half an inch to 3 inches in thickness, which may be called, for want of a better term, shelly lime rock, on account of its laminated condition. This rock is not seen as far west as Fort Scott, but has an equivalent in a calcareous clay of a few inches, and containing fossils such in all respects as I have just described. These shales carry sandstone in certain localities which are quite firm, but possibly not firm enough for building purposes. Such a condition is found a couple of miles west of the state line, in the road, directly east of Fort Scott."

PAWNEE LIMESTONE.[9]

First above the Labette shales lies a bed of limestone known as the Pawnee limestone, which is of sufficient extent and continuity to make it an important stratigraphic feature and therefore suitable for a distinct name.

Areal Extent of Pawnee Limestone.

The Pawnee limestone is most prominent in the vicinity of Fort Scott. Here it covers the surface on all of the hills in every direction from the city and extends southward at or near the surface to Farlington along the Kansas City, Fort Scott & Memphis railway line. Eastward it outcrops on the hills east of the city, and northward reaches to beyond Hammond.

Its line of outcropping may be described tolerably well by saying that it occupies an escarpment prominent in some places and elsewhere almost indistinct, which passes from two to five miles to the west of the outcropping of the Oswego limestone already described. Beginning on the north it may be located as follows: It crosses the state line into Missouri at the extreme northeastern corner of Bourbon county; it passes upwards along a small tributary of the Little Osage for a distance of four or five miles into Linn county, thence veering to the west it disappears under the water of the Little Osage between nine and ten miles west from the state line. It follows the bluffs on the south side of the Little Osage eastward, again

9. Swallow: Geology of Kansas, p. 24, Lawrence, 1866.

crossing into Missouri, but reappears in Kansas along the bluffs north of the Marmaton, up which stream its outcropping bears westward for a distance of seventeen miles. It again bears back east on the south side of the Marmaton to the state line and finally veers westward again in an exceedingly irregular line passing just west of Girard, thence by McCune, Laneville, Parsons, and Stover into the Indian Territory, along the median line of Labette county. Its outcropping is well represented on the map, Plate VII.

To the west and northwest the Pawnee extends under the surface for a distance as far as any of our drills have given us data. At Stover, Mound Valley, and Cherryvale it is easily recognized, gradually increasing in thickness to the west. At La Harpe and Iola it is also easily recognized, although the shales between it and the Oswego limestones have become quite thin. At Toronto it has almost coalesced with the Oswego limestone, the two together forming a mass of limestone, with but little interbedded shale, aggregating 75 feet in thickness. To the north it is continuous as far as Doniphan, as is plainly shown by the wells at Paola, Iola, Olathe, Kansas City, Leavenworth, and Doniphan.

Characteristics and Thickness of Pawnee Limestone.

The thickness of the Pawnee limestone varies greatly in places where it is exposed to the surface. At Fort Scott it is about thirty feet thick. Both to the north and to the south, as exposed to the surface, it perceptibly decreases in thickness. Whether this is due entirely to surface erosion or partially to the normal condition of the rock is difficult to say, but probably to the latter. The thickness which it possesses underground, further to the north, likewise varies, but in general increases to the westward until, as shown above at Toronto, it has a thickness of 40 or 50 feet.

The general characteristics of the Pawnee limestone are quite distinct from those of the Oswego limestone below it or from the Altamont limestone above it. These characteristics are best represented in the vicinity of Fort Scott where it forms

great boulders, covering the country, many of them being from 5 to 15 feet across and from 2 to 4 feet in thickness. Here the individual beds are unusually thick and heavy, making such large boulders possible. It is unusually white in color so that the boulders produced from it, when seen at a distance, present a beautiful appearance in the landscape. It more closely resembles the massive and crystalline appearance of the Iola limestone than does any other limestone in the Coal Measures of Kansas.

The following fossils have been found in the Pawnee limestone: *Cyanthaxonia distorta, Lophophyllum proliferum, Chætetes milleporaceus, Fistulipora nodulifera, Athyris subtilita, Productus longispinus, Spirifera lineata, Spiriferina kentuckiensis, Pleurotomaria sphærulata.*

PLEASANTON SHALES.[10]

Immediately above the Pawnee limestone lies a heavy bed of shales, important in many particulars. It has already been described[11] as occupying a position between the Pawnee limestone below and the Erie limestone above. Bennett,[12] however, noted that midway between the two limestone boundaries was another limestone which in his section from Fort Scott to Yates Center he found to be 8 feet thick, but, as it was supposed that it did not extend very far laterally, it was not named. During the summer of 1897 Doctor Adams discovered that this 8-foot limestone of Bennett's is continuous with the Altamont limestone already described, and occupying a well known horizon to the south. It therefore becomes advisable to give a distinct name to the shale between the Pawnee and the Altamont limestones. Adams traced the Altamont limestone from the south side of the state northward to the section already run by Bennett from Fort Scott to Yates Center. Here, the same season, Mr. Bennett took it up and carried it beyond the divide north of the Osage river, but it gradually grew thinner and entirely

10. Haworth: Kansas University Quarterly, vol. iii, p. 274, Lawrence, 1895.
11. University Geological Survey of Kansas, vol. i, pp. 22, 44, 74, 93, and 153, Lawrence, 1896.
12. Loc. cit., p. 94.

disappeared before the high bluffs in the vicinity of Boicourt and La Cygne were reached.

The following is his note book description of its northern extension:

"It is easily traced north as far as the divide north of the Osage river in Linn county, but beyond that it is uncertain. Its northeast trend into Missouri could not be found, but it probably passes as far northeast as Prescott. It dips under the Little Osage near the Missouri Pacific railroad bridge a little below Mapleton. It is the same everywhere in lithologic characteristics. Its equivalent is perhaps the thin limestone found in the hills near Fort Scott, although I am inclined to think the latter to be one of the thin limestones in the Upper Pleasanton shales. There are patches of rock southeast of Pleasanton that might with safety be placed as its equivalent. No limestone was found in any of the mounds, of which there are so many in the neighborhood of the Marais des Cygnes, that would take its place. Its stratigraphic position would be near the base of these mounds, but it was nowhere seen."

It would appear, therefore, that should we give a distinct designation to the lower shales in the south, differing from that given to the upper, it would be difficult to decide which name should apply to the shales lying north of the northern extension of the Altamont limestone. Yet the shales lying between the Pawnee and the Altamont are so important in many ways that they deserve a distinct characterization. We will, therefore, speak of them as the Lower Pleasanton shales, and the shale bed lying between the Altamont and the Erie limestones as the Upper, leaving the original and unqualified name, Pleasanton shales, applicable to the whole bed north of the northern extension of the Altamont limestone.

Lower Pleasanton Shales.

This division of the Pleasanton shales is important from both the theoretic and the economic standpoints. It carries a large amount of coal and also flagging stone of great commercial importance. Along the section west from Fort Scott—Plate II—in the bluffs of the Marmaton near Redfield they are about a hundred feet thick; at La Harpe they have dropped to but 75 feet; at Iola 50; and at Toronto they have increased to 72 feet. Along this section and to the north they are not more than half as thick as the Upper Pleasanton shales, and will average per-

haps not more than one-third. Southward from this section they increase in thickness. At Altamont they are fully a hundred feet thick; at Mound Valley 111 feet; at Cherryvale 124 feet; while judging from the prominence of the divide, south from Altamont their thickness appears to increase.

Coal in the Lower Pleasanton Shales.—The Lower Pleasanton shales carry a large amount of coal. This is noted in many places. At Redfield the coal lies but a short distance above the Pawnee limestone and is from 6 to 10 inches in thickness. Northward it increases in thickness and in areal extent. North of Fort Scott and in the vicinity of Hammond, Fulton, and Prescott coal has been mined in scores of places by the strip pit process, all of which coal comes from the Lower Pleasanton shales. At Pleasanton, Boicourt, Mound City, La Cygne, and adjacent territory coal is likewise mined to a great extent from the same shale beds, or from the lower part of the Pleasanton shales north of the limits of the Altamont limestone. In some localities this coal reaches a thickness of 3 feet, making it perhaps the most important coal bearing shale bed above the Cherokee shales.

Flagging Stones in the Lower Pleasanton Shales.—The Lower Pleasanton shales also carry large quantities of excellent flagging stone which is extensively quarried at many places to the west of Fort Scott in the vicinity of Redfield, Bandera, and Gilfillan, and farther south near Farlington. The quality of these flags is unsurpassed, in many places great quantities of them being available, of smooth surface and uniform thickness, of any dimension desired. Their surfaces are covered with wave marks and ripple marks, showing that they were formed in shallow water where the tidal waves were spreading the sands on the bottom of the ocean near the shores.

Upper Pleasanton Shales.

The shales lying above the Altamont limestone possess neither coal nor flag stone of economic importance and but little of special scientific interest. Northward they are heavier than

the Pleasanton shales and southward lighter. Just west of Uniontown, in the escarpment covered by the Erie limestone, they are at least 130 feet thick; at La Harpe 150 feet; at Iola 160; and at Toronto 160 feet thick. Southward in the vicinity of Mound Valley, Cherryvale, and Coffeyville they are again divided into not less than four distinct shale beds separated by individual limestone horizons which converge northward and constitute the Erie limestone. At Cherryvale the uppermost member of the Erie limestone, which in reality limits the upper part of the Pleasanton shales, has been called the Independence limestone and will be described later in this report. Immediately below it there is a bed of shale at least a hundred feet thick which forms the body of the mounds and escarpments in the vicinity of Cherryvale, as well as the Bender mounds to the northeast.

Pleasanton Shales North of the Altamont Limestone.

Northward beyond the limits of the Altamont limestone the Lower and Upper Pleasanton shales coalesce, forming a heavy shale bed which was first described[13] as the Pleasanton shales. At Boicourt they are fully 200 feet thick. Northward they decrease in thickness to the vicinity of Paola, beyond which they again increase to about 200 feet at Kansas City. They constitute the main shale bed which assists in producing the heavy escarpment so prominent in the vicinity of Mound City, Pleasanton, Boicourt, La Cygne, and other places to the east in Missouri. To the west and southwest of Mound City they likewise are prominent along the bluffs of Sugar creek and its tributaries in the western part of Linn county, as well as the bluffs along the Osage river and its tributaries below Paola. The extraordinary amount of sandstone contained in the Lower Pleasanton shales in the vicinity of Redfield, Gilfillan, etc., has already been described. The uppermost part of the shales in many places carries heavy beds of sandstone. At Boicourt a bed of sandstone 10 feet in thickness occupies a position almost at the very summit of the shales. The lateral extent of this

13. Haworth: Kansas University Quarterly, vol. iii, p. 274, Lawrence, 1895.

sandstone is comparatively great as it can be found everywhere throughout the entire extent of the heavy escarpment already mentioned. The well records at La Harpe show 20 feet of sandstone near the top of the shales. The well at Iola shows 60 feet of sandstone and sandy shales; the one at Toronto, about 35 feet of sandstone and sandy shales, all of which is located at the summit of the Pleasanton shales and therefore corresponds to the sandstone exposed along the bluffs of Sugar creek and the Osage river. In many places wave marks and riffle marks abound in the sandstone, showing the coastal character of the deposit.

Stratigraphically the Pleasanton shales are of great importance as they constitute an unusually heavy bed of shales throughout the whole of southeastern Kansas and therefore can usually be recognized when reached with the drill or when observed at the surface. In general character they are similar to the Cherokee shales and stratigraphically are very important. They are the third heaviest shale beds in the whole Coal Measures of Kansas. They show a repetition of the general physical conditions which obtained throughout the period during which the Cherokee shales were deposited, both as to the extraordinary growth of vegetable matter and the production of heavy beds of coal therefrom as well as the extensive accumulation of coastal arenaceous deposits, implying shallow water conditions. Their great lateral extent from north to south and from east to west, as shown by their surface exposures and by the records of the scores of deep wells in the state, likewise make them important stratigraphic landmarks.

As already explained at considerable length[14] the upper limit of the Pleasanton shales has been made the division line between the Lower and Upper Coal Measures of Kansas. Recent investigations in the stratigraphy confirm the desirability of this location. From the stratigraphic and lithologic properties of the different terranes no more favorable point could be found for making a great division. This line of separation, therefore, will be retained.

14. Haworth: University Geological Survey of Kansas, vol. i, p. 179, Lawrence, 1896.

ERIE LIMESTONES.[15]

At the close of the Pleasanton shales period a great limestone forming period was ushered in. Conditions were favorable for limestone production throughout a wide area reaching from the southern part of Kansas northeastward to Kansas City, as shown from investigations in this state, and probably continuing northward and northeastward through Missouri and Iowa. These limestones, following the heavy Pleasanton shale beds, are all the more prominent in their surface exposures. Producing a protecting cap to the shale, they have assisted in forming prominent escarpments which are noticeable entirely across the state and which are particularly prominent throughout the greater part of this distance. The limestone formed is not one continuous layer a hundred or more feet in thickness, but a number of layers separated from each other by shale beds and shale partings varying in thickness from each other and each individual parting varying in thickness in different places throughout this extent. Yet the limestones, as a whole, are closely related and may, therefore, be referred to as one limestone system which is everywhere in strong contrast with the heavy shale beds underneath.

The Erie limestones are well represented west of Fort Scott, producing the heavy escarpments just west of Uniontown. Here, as described by Bennett,[16] there are three distinct limestones, which caused him to speak of the system as the "triple limestone system" when making his preliminary report, a term which has crept into print, but which was used merely as a local designation. His description of the detailed section west of Marmaton may be inserted.

"In detail these limestones are as follows: Beginning at the bottom of the series there is first a dark limestone 16 inches thick in two layers, and above it 3 feet of drab clay shale. Upon this lies 22 feet of unevenly and very heavily bedded limestone, projecting from the sides of the ravines like unto turreted walls. Immediately above this is 7 feet of clay shale, then again 3 feet of evenly bedded limestone in two layers, above which lies 4 feet of clay and bituminous

15. Haworth and Kirk: Kansas University Quarterly, vol. ii, p. 188, Lawrence, January, 1894.
16. Bennett: University Geological Survey of Kansas, vol. i, p. 95, Lawrence, 1896.

shales. Again we come to 16 feet of limestone—the lower portion somewhat evenly bedded, the middle heavily bedded and near to the top brecciated, with few vertical seams—then the top section a somewhat silicious limestone, diagonally laminated in places, like unto some of our sandstones, all standing out in many localities in bold relief along the ravines. Above this is 9 feet of somewhat argillaceous shale, and on these shale we again find a limestone 1½ feet thick, in two layers also evenly bedded. Above this again there is 3 feet of bituminous shale, and superincumbent on this is our third limestone 25 feet in thickness. The lower 20 feet of this last is evenly bedded white limestone with an occasional chert concretion buried in it, but the upper 5 feet is a very cherty rock, around the cherts of which there is much chalky matter. This chert forms a coarse gravel overlying the hills in the vicinity of its immediate outcrop."

Southward from this section the shale partings increase in thickness and the limestones decrease correspondingly until in the vicinity of Cherryvale the limestones are separated by a hundred or more feet of shale, and some of them have become so thin that they have lost much of their stratigraphic importance. Still further southward the decrease of the limestones continues so that along the state line the uppermost one, the Independence limestone, is the only one of much importance. Northeastward from Uniontown, on the other hand, their thickness is maintained and their importance as well. They are prominent in the vicinity of Pleasanton, Boicourt and La Cygne, Osawatomie and Paola, and further northeast into Missouri and are occasionally visible from Osawatomie to Kansas City along the deep valleys of streams which have cut their channels through them. At Kansas City the lowermost member of the system is the Bethany Falls limestone of Broadhead,[17] No. 78 of his section. Opposite Uniontown the whole system is nearly 125 feet in thickness; at La Harpe they have increased to about 175 feet; at Iola to 200 feet; and at Toronto to 225 feet in thickness. Like the limestones below they increase in thickness and massiveness of character to the west, as is shown by all the wells drilled through them.

The general physical characters of the Erie limestones are not particularly different from those of other Coal Measure limestones, except the upper bed which, as Bennett has shown, is remarkable for the large amount of chert or flint rock it car-

17. Broadhead: Missouri Geological Survey, Report 1872, Part ii, p. 97.

ries. As the limestone wears away this chert is left behind, forming great gravel beds which are abundant over the entire surface of the country. Many pieces of the chert are from two to four feet long, weighing hundreds of pounds, while other masses are small and so full of fracture seams that when liberated by the weathering of the limestones they form pebbles of varying sizes even to small gravel. No other limestone in the whole Kansas Coal Measures produces as much flint as this one which, in this respect, resembles the Permian limestones of the Flint Hills.

The Erie limestones abound in fossils from the list of which the following may be selected as representatives: *Fusulina cylindrica*, *Axophyllum rudis*, *Campophyllum torquium*, *Archiocidaris mucronatus*, *Archiocidaris triserrata*, *Erisocrinus typus*, *Eupachycrinus tuberculatus*, *Scaphocrinus hemisphericus*, *Zeacrinus acanthophorus*, *Serpula incita*, *Spirorbis carbonaria*, *Fenestella* ——, *Polypora submarginata*, *Synocladia biserialis*, *Chonetes granulifera*, *Chonetes smithi*, *Chonetes millipunctatus*, *Orthis precosi*, *Orthis robusta*, *Orbiculoida* ——, *Productus americana*, *Productus pertenuis*, *Productus symmetricus*, *Syntrialasma hemiplicata*, *Terebratula bovidens*, *Allorisma granosa*, *Allorisma reflexa*, *Allorisma subcuneata*, *Aviculopecten carboniferus*, *Aviculopecten interlineatus*, *Aviculopecten providencensis*, *Aviculopecten americana*, *Chænomya leavenworthensis*, *Conocardium obliquan* (very rare), *Edmondia aspinwallensis*, *Edmondia ovata*, *Edmondia reflexa*, *Macrodon carbonarius*, *Monopteria gibbosa*, *Myalina subquadrata*, *Myalina swallowi*, *Nucula parva*, *Pinna paracuta*, *Pleurophorus oblongus*, *Scizodus wheeleri*, *Solenopsis solenoides*, *Bellerophon crassus*, *Loxonema rugosa*, *Naticopsis gigantia*, *Platyceras nebrascense*, *Pleurotomaria turbiniformia*, *Pupa vitusta*, *Conularia cristula*, *Goneatites lyoni*, *Nautilus occidentalis*, *Nautilus ponderosus*, etc.

The southern extension of the Erie limestones, where the individual members are separated by heavy shale beds, deserves special attention. The lowermost member, which probably is a continuation of the Bethany Falls limestone, outcrops along an intermediate escarpment noticeable between Altamont and Mound City. The limestone as such has little significance.

Above this lies the heavy bed of shales which constitutes the escarpment to the northwest of Mound Valley. These shales may be called the Mound Valley shales.

Mound Valley Shales.

They are prominent throughout a distance of twenty to thirty miles and form the mounds giving the name to Mound Valley. In general character they are similar to the other shales of the Upper Coal Measures, varying from a light ashy color to a jet black. Along the bluffs of Hill creek, west of Mound Valley, where a good section of the shales may be seen for miles in extent, it is noticed that some of them are light in color while others are black. They also carry sandstone here and there very like the Lower Coal Measure shales.

Mound Valley Limestone.[18]

Overlying the Mound Valley shales is a limestone varying in thickness from 5 to 10 feet, which corresponds to the middle one of the Erie limestones. On account of its being so far separated vertically, and therefore horizontally, from the other members of the Erie limestones in this vicinity it would not be amiss to designate it by the term Mound Valley limestone, as Adams has done, as it constitutes the covering upon the hills near Mound Valley. This limestone is particularly fossiliferous, many brachiopods and lamellibranchs occurring in it, excellent specimens of which may be obtained along the bluffs of Hill creek. To the northwest well records show that this limestone gradually thickens and approaches in vertical distance the other members of the Erie system.

Cherryvale Shales.

Above the Mound Valley limestone lies a bed of shales 120 feet in thickness which is prominent from Coffeyville north almost to the Neosho river. These are the shale beds separating the middle and upper members of the Erie limestone. From the Verdigris river northward by the way of Cherryvale and Mortimer they produce an escarpment and a series of isolated

18. Adams: University Geological Survey of Kansas, vol. i, p. 23, Lawrence, 1896.

bluffs which are as prominent as any escarpments and bluffs in the state. This is particularly true in the vicinity of Cherryvale where the valley of Drum creek cuts off a row of mounds on the east from the prominent escarpment along its western bluffs. Northeast of Cherryvale the mounds are locally designated as the Bender mounds, an allusion to an important historical event which occurred in their midst. These Cherryvale shales have no special properties different from the Mound Valley shales and could scarcely be distinguished from them by physical or paleontological properties.

Independence Limestone.[19]

The upper member of the Erie limestone system, on account of its prominence in the vicinity of Independence, has been named Independence limestone. Along the southern part of the state this limestone occupies the summit of the hills and mounds and caps the escarpments already described as being largely due to the existence of the thick bed of Cherryvale shales. It has lost the flint which the same horizon carries, in the vicinity of Uniontown. Here its most characteristic properties are the large number of invertebrate fossils it carries an unusually large proportion of which belong to lamellibranchiata and gasteropoda, the more important specimens of which have already been given in the fossils common to the Erie limestone. In many places the fossils are so abundant that the limestone when dressed presents a beautiful variegated appearance and probably could be successfully worked into ornamental table tops and other similar uses.

The Independence limestone dips rapidly to the west from Cherryvale to beyond Independence, making one of the steepest inclinations known in the state. At Cherryvale it is about 935 feet above sea level. From Cherryvale to Independence it dips to about 800 feet, or 15 feet to the mile, while at Howard it was reached in a well at a depth of 75 feet below sea level. Howard is 40 miles on an air line to the northwest of Cherryvale, which would make the Independence limestone dip from the hill

19. Adams: University Geological Survey, vol. i, p. 23, Lawrence, 1896.

MOUND VALLEY LIMESTONE.

Hill northwest of Mound Valley. (Photographed by Adams, 1894.)

VERDIGRIS RIVER AND INDEPENDENCE LIMESTONE.

Independence. (Photographed by Adams, 1894.)

MOUND SOUTH OF CHERRYVALE CAPPED WITH INDEPENDENCE LIMESTONE.

(Photographed by Haworth, 1894.)

SURFACE EXPOSURE OF INDEPENDENCE LIMESTONE.

Southwest of Cherryvale. (Photographed by Adams, 1894.)

HILL NORTH OF CHERRYVALE CAPPED WITH INDEPENDENCE LIMESTONE.

(Photographed by Haworth, 1894.)

HILL CAPPED WITH INDEPENDENCE LIMESTONE.

North of Cherryvale. (Photographed by Adams, 1894.)

TABLE MOUND, NEAR INDEPENDENCE, CAPPED WITH IOLA LIMESTONE.

(Photographed by Adams, 1894.)

TABLE MOUND, NEAR INDEPENDENCE, CAPPED WITH IOLA LIMESTONE.

(Photographed by Adams, 1894.)

tops around Cherryvale at an avearge of 25 feet to the mile. It likewise thickens rapidly to the northwest, the increase of the Erie limestone, already described, being largely due to the thickness of the Independence limestone. To the south and southwest it gradually decreases in thickness, while the shale beds, both above and below it, correspondingly increase.

THAYER SHALES.[20]

At the close of the long period during which the Erie limestone system was formed a heavy bed of shales was produced which constitutes an important terrane in the Upper Coal Measures of Kansas. Immediately above the Independence limestone these shales are found which have been studied in detail over a considerable portion of Neosho, Wilson, and Montgomery counties and further to the northeast. Also they are recognizable further to the west and northwest in the records of every oil and gas well carried to a sufficient depth to reach them. They are prominent in the vicinity of Chanute, Thayer, Neodesha, Fredonia, and other points in that vicinity, where they reach a thickness of fully 200 feet and constitute the great body of the hills and outlying isolated mounds and prominent escarpments to the west and northwest of Independence and Neodesha. The Verdigris river and its various tributaries have cut wide and deep channels through the overlying limestone and into the shales, forming high bluffs along their courses. This escarpment, traced to the northeast, is prominent as far as Moran, beyond which its importance gradually diminishes on account of the thinning of the shale beds until, from Mound Valley north, the shales become so thin that the escarpment produced by them practically coalesces with that produced by the Erie limestone underlying the Pleasanton shales. Their southeastern outcropping crosses from Kansas into Missouri as has already been explained for the Pleasanton shales. Westward and northwestward well records show that their thickness gradually decreases. At La Harpe they are but 100 feet thick,

20. Haworth: Kansas University Quarterly, vol. iii, p. 276, Lawrence, 1895.

and at Toronto they are 90 feet thick, showing a constant decrease in thickness in a westerly direction.

In general character the Thayer shales are similar to the Pleasanton shales and the Cherokee shales. They carry a large quantity of coal and sandstone. The coal is most abundant near the surface to the west and southwest of Thayer where it is mined by stripping and by tunneling, and it supplies a large local demand. The coal reaches a thickness of from 12 to 20 inches and is fair in quality.

The sandstone of the Thayer shales is variable, sometimes forming broad thin layers and elsewhere constituting heavy beds with thick layers which would supply large blocks of dimension stone. It is not, however, of much value as a building material. It is poorly cemented and in places is irregularly marked with iron oxide forming an uneven color.

The sandstone and the sandy shales almost everywhere carry ripple marks and other indications of being shallow-water deposits. In fact they have as strong internal evidence that they are marginal deposits be can be found anywhere in the Cherokee or Pleasanton shales.

A few thin limestone beds likewise occasionally are found in the Thayer shales, none of which have sufficient thickness or lateral extent to be of much importance stratigraphically. Two or more of these may be seen along the Verdigris valley between Independence and Altoona; one of them, quite oolitic in character, may be seen on the bluff west of the bridge over the Verdigris north of Independence; the second is exposed principally between the bridge and Neodesha on the east side of the river; a third is found northeast of Neodesha along Chetopa creek; and one of these is readily recognized in the bluffs west of Neodesha, although it cannot be definitely correlated. In the vicinity of Kansas City where the Thayer shales are comparatively thin several of the lesser limestone series are noted between the Erie and the Iola limestones, which occupy a position corresponding to those just mentioned. It is evident, however, that they are not continuous from Kansas City to the southwest as many well records show their absence.

Earlton Limestone.

But heavier still and more persistent than any of the lesser limestones just mentioned is one occupying a position near the summit of the Thayer shales which develops into a prominent ledge that has exercised a strong and marked influence on the topography of the country to the west and northwest of Earlton, for which Doctor Adams has suggested the name Earlton limestone. West of Sycamore the Earlton limestone is separated from the Iola limestone by a comparatively thin bed of shales which thickens further north towards Guilford and Chanute so that the limestone is further removed from the overlying Iola limestone. This permits the production of a prominent escarpment by the Earlton limestone which is a prominent feature of of the landscape to the west of Earlton and Chanute.

The Earlton limestone has been traced in detail no further north than the Neosho river. What its northern limit is cannot be stated definitely, but it is known that it cannot be traced much beyond the Neosho river. We therefore have a lenticular mass appearing prominently at certain places and gradually growing thinner both to the north and to the south until it entirely disappears.

Vilas Shales.

The shale bed occupying the position between the Earlton limestone and the overlying Iola reaches a thickness of 75 feet or more immediately west of Chanute and Earlton. For convenience in local description it may be recognized as a distinct shale bed, although when traced to the north or to the south it coalesces with the Thayer shales upon the disappearance of the Earlton limestone. Doctor Adams has suggested that this shale bed might be designated the Vilas shales, as it is well represented around the little town of Vilas on the Santa Fe railway between Chanute and Benedict.

IOLA LIMESTONE.[21]

Above the Thayer shales an unusually prominent limestone horizon exists which has been named the Iola limestone. No limestone in the state is more important stratigraphically than this and no one reaches a greater thickness or has a greater lateral extent. Its southeastern outcropping marks a prominent terrace from the south line of the state, a few miles west of Independence, to the Missouri state line in the northeastern part of Miami county. The escarpment here passes into Missouri but soon veers westward again, crossing back into Kansas in the southeastern part of Johnson county, from which place it follows an irregular course to the northeast to a few miles east of Kansas City.

The Missouri river and all of its tributaries near Kansas City have cut through the Iola limestone and the underlying Erie limestone forming high bluffs on either side of their valleys. At Kansas City the Iola limestone is the most prominent of the rocks in the bluffs and measures about 30 feet in thickness. The thickness of the rock along its line of outcropping is variable, dependent partially upon its original form and partially upon the extent to which erosion has reduced it. Likewise the escarpment which it covers varies in thickness and in prominence, dependent principally upon the thickness of the underlying Thayer shales. As before explained the Thayer shales are heaviest to the southwest. Northward, as they gradually become thinner, the Iola escarpment approaches the escarpment produced by the Erie limestone. In the southern part of the state these two heavy escarpments are from ten to twenty miles apart, but to the northeast their lines converge until in Linn county they almost coalesce. From here northward they practically become the same, constituting the Bethany escarpment of the Missouri geologists.

The westward extension of the Iola limestone is known to be great, reaching probably far beyond the limits of our knowl-

21. Haworth and Kirk: Kansas University Quarterly, vol. ii, p. 109, Lawrence, 1894.

edge, which does not extend beyond the deep wells of Howard, Toronto and other points. In the bluffs at Kansas City the limestone is 30 feet thick. At Iola, a few miles to the west of its outcropping, it is 40 feet thick. The Fall River well found it to be 100 feet thick. The Howard well revealed a thickness of over 200 feet for the Iola limestone, assisted probably by a few lesser ones which do not reach the surface. The Toronto well likewise shows that the Iola limestone has a thickness of about 200 feet at that place. To the far north, beyond Kansas City, the Thayer shales seem almost to disappear, at least to lose their identity as far as can be judged from the well records. The Iola limestone, therefore, practically coalesces with the underlying Erie limestone, making it difficult to distinguish between the two. The Leavenworth well, the Atchison well, the Doniphan well, and other deep wells in that part of the state show a large amount of limestone corresponding to the Iola and to the Erie, implying at least that limestone forming conditions existed for a long period almost to the exclusion of the formation of important shale beds.

The Iola limestone is important regarding some of its physical conditions. Its most noted characteristic is the absence of vertical fissures within it, thus permitting the existence of large blocks of the limestone on the hillsides where they have fallen by the undermining processes of decay. It also renders it most valuable as a quarry stone, making it possible to obtain dimension blocks of any desirable proportion. The quarries at Iola have produced as large blocks as was desired and doubtless much greater ones could be obtained were mechanical devices at hand to lift them.

The Iola limestone also is remarkable an account of its highly crystalline character. No limestone in the whole Coal Measures of the state is crystallized to a greater extent than this. In many places parts of it, in fact, are almost a perfect marble, the crystallization is carried to so high a degree of perfection. This crystalline character is not, however, everywhere noticeable to the same extent. In the bluffs of Kansas City it is not promi-

nent, nor is this property particularly noticeable along the south line of the state.

The Iola limestone carries a great many fossils, although in general appearance it does not seem to have as many as some of the other limestones. Apparently the greater part of the formation was deposited in deep ocean water where the conditions were not the most favorable for the accumulation of fossils. Elsewhere north or south from such a location a larger number of fossils may appear. Of these the following species of invertebrates may be taken as types of those the most abundant: *Michelinia eugeneæ, Athyris subtilita, Lingula scotica, Productus longispinus, Productus pertenuis, Spirifera camerata, Spirifera lineatus, Aviculopecten carboniferus, Pinna subspatulata, Nautilus occidentalis, Nautilus missouriensis.*

LANE SHALES.[22]

Above the Iola limestone lies a heavy bed of shales which, contrary to the conditions of the shale beds occupying a lower horizon, thickens to the north. The upper limit of the shales is determined by the Garnett limestone, a prominent limestone horizon from Garnett northward to beyond the limits of the state at Leavenworth, which, however, across the Neosho river to the southward gradually decreases in thickness and at the same time approaches the Iola limestone. The Lane shales therefore cannot be traced with certainty to the south line of the state. Probably they are represented by the thin bed of shales immediately above the Iola limestone shown in Plate I. At Garnett and in the Howard well opposite Moline and to the northeast they are very prominent, and with the overlying Garnett limestone form a heavy and prominent escarpment line from near Carlyle to the Kansas river bluffs near Argentine by the way of Kincaid, Garnett, Greeley, Lane, and Paola.

At Lane and other points along the Pottawatomie river they vary from 75 to 100 feet in thickness. Frequent outlying mounds are noticeable here and there from Lane to Osawa-

22. Haworth: University Geological Survey of Kansas, vol. i, p. 49, Lawrence, 1896.

tomie and their physiographic features are well marked, which could not occur without the existence of a comparatively heavy bed of shale. Northward from Paola the shales gradually decrease in thickness. Along the Kansas river bluffs from Argentine to Eudora, throughout the whole of which distance they are exposed, the average thickness which they maintain does not exceed 40 feet, and in many places they are not 10 feet thick. A drilled deep well at Lawrence likewise shows that here their thickness is not greater than along the river bluffs. The Topeka well, on the other hand, shows that the limestones at that place are not as heavy as one might reasonably expect from the conditions elsewhere, and that the shale beds in general, including the Lane shales, have greatly thickened.

The general character of the Lane shales has but little special interest. They carry a smaller amount of sandstone than do the heavy shale beds already described, and practically no coal. They have more indications of being deep water deposits than any shale beds thus far described. On account of their great irregularity in thickness, they almost entirely disappear both to the south and to the north. They are therefore less important stratigraphically than some of the other shale beds of the Kansas Coal Measures.

GARNETT LIMESTONES.[23]

Above the Lane shales the Garnett limestones are found. The name is applied to two different limestone horizons separated from each other by a thin and relatively unimportant bed of shale. They are prominent at Carlyle, Garnett, Ottawa, Lane, Paola, Olathe, and Argentine, and are exposed over an unusually wide zone, trending in a northeast and southwest direction. This is due to the heavy Lawrence shales overlying them having been eroded away much further to the west than the other shale beds usually are, leaving the Garnett limestones as a floor covering a wide area of country. The shale bed between the two limestones is so thin that the eastern outcroppings of the two usually are the same.

23. Haworth and Kirk: Kansas University Quarterly, vol. ii, p. 110, Lawrence, 1894.

In previous descriptions it has been thought that the limestone exposed at Carlyle was distinct from the Garnett limestones and therefore the term Carlyle limestone was introduced. But during the summer of 1897 Bennett discovered that the so-called Carlyle limestone was the same as the Garnett. As the latter name had been used much more extensively than the former, and the two first used at the same time by the writer, it is preferable to retain the name Garnett and to entirely do away with the name Carlyle.

The thickness of the Garnett limestones along their line of outcropping varies more, perhaps, than that of any other system of limestone known in the Coal Measures. On the south side of the Neosho river they are relatively unimportant, the Lane shales being so thin the Garnett limestones almost coalesce with the Iola. Northward they gradually increase in thickness, being perhaps 25 feet thick at Carlyle. In the vicinity of Lane their thickness is more than double this, while opposite Olathe the lower one of the two has a thickness of more than 50 feet and the upper one nearly as great. At Argentine and other points westward along the Kansas river bluffs to Eudora their thickness is not so great, varying from 10 to 20 feet, as is also found to be the case at Ottawa, Princeton, and other points in that vicinity. Westward they gradually increase in thickness again, reaching about 65 feet at Toronto, where the shale parting between the two seems to have entirely disappeared and they are separated from the Iola limestone by about 16 feet of Lane shales.

The Garnett limestones are particularly rich in invertebrate fossils, of which the following may be taken as representatives: *Campophyllum*(?), *Fenestella*(?), *Synocladia biserialis*(?), *Derbya*(?), *Productus americanus*, *Productus semireticulatus*, *Syntrialasma hemiplicata* (very abundant in places), *Myalina kansasensis*, *Myalina recurvirostris*, *Euomphalus subrugosus*, *Naticopsis altonensis*, *Pleurotomaria tabulata*, *Nautilus occidentalis*, and about forty other species.

LAWRENCE SHALES.[24]

First above the Garnett limestones we find an unusually heavy bed of shales which stratigraphically is as important as any shales in the whole Kansas Coal Measures. On account of their great prominence in the vicinity of Lawrence they have been called the Lawrence shales. They extend entirely across the state from Leavenworth on the north to Sedan on the south, their eastern outcropping forming a prominent escarpment throughout this whole distance by way of Lawrence, Ottawa, Burlington, Yates Center, Toronto, and Longton.

Their thickness at Lawrence is fully 300 feet. Southward this thickness appears to decrease to beyond Ottawa and Burlington, from which locality it rapidly increases southward and apparently reaches a thickness of nearly 800 feet along the south line of the state, as is shown by the deep well at Niotaze and others in that vicinity. It would seem that the underlying limestones above the Iola, as already explained, decrease southward and either entirely disappear or practically coalesce with the Iola limestone, while the Oread limestone above, which bounds the upper surface of the Lawrence shales, is almost horizontal in its southern extension, or if varying at all rises slightly. In this way the Lawrence shales are thickened to the 800 feet or more. Northward from Burlington and Ottawa their thickness increases to Leavenworth where they are nearly 300 feet thick, from whence they again decrease, as is shown by the Doniphan well which reached the bottom of the shales at 134 feet below the surface. The exact location of this well being unknown to the writer, it cannot now be stated how far below the Oread limestones the well started, but it is readily seen that the Oread limestones dip northwestward rapidly from Leavenworth, which must decrease the thickness of the underlying Lawrence shales.

Sandstone in the Lawrence Shales.

Sandstone abounds in the Lawrence shales. Wherever found the shales are more or less arenaceous, and in many places this

24. Haworth: Kansas University Quarterly, vol. ii, p. 122, Lawrence, 1894.

quality is carried to the extreme, producing well formed heavy beds of sandstone. This is true throughout their whole exposure from Leavenworth to Sedan, but more particularly so south of the Neosho river. The sandstone is variable in appearance, but is always characterized by many features of shallow deposits. Everywhere wave marks abound and are the most prominent and the best preserved of any ever examined by the writer. The continuity of these sandstone beds is not great; frequently a change will occur in a mile or less which alters a well formed sandstone into a soft arenaceous shale. It is difficult to decide what part of the Lawrence shales carries the most sand, whether the lower, the middle, or the upper. In fact no distinction of this kind can be made.

South of the Neosho river, where the Lawrence shales have so greatly increased in thickness, the proportion of sandstone likewise has greatly increased. The driller's record of the Niotaze well shows that there was an unbroken continuity of sandstone from the surface to the depth of 670 feet, from which depth shale was passed through for 130 feet, reaching the uppermost limestone at a depth of 800 feet. The surface conditions east of Niotaze, where the sandstone strata outcrop, indicate that the sandstones alternate with thin shale beds which the well record as preserved fails to show; also the outcroppings west of Niotaze show that the strata superior to those passed through by the well consist of alternating beds of shale and sandstone, with the sandstone the most prominent.

The wide zone through which the Lawrence shales are exposed to the surface, being from fifteen to twenty-five miles in width south of the Neosho river, is an exceedingly sandy and hilly country. The sandstones alternating with the softer shales have produced by erosion an irregular topography difficult to describe and unequaled in general irregularity anywhere in the state. From Burlington and Neosho Falls to the southwest by way of Yates Center, Benedict, New Albany, Buxton, Colfax, Sedan, Peru, and Chautauqua, this sandstone and the corresponding irregular surface occupy the whole country.

Doctor Adams has suggested that the sandstone here is suffi-

ciently prominent to merit a distinct local designation, and has proposed for it the name "Chautauqua Sandstone." The following description of the area is taken from his note book:

"Passing south from the Neosho river the shales grade into sandstones so that at Yates Center they become conspicuous, producing the hill on which the town is built. The area broadens to the south, its eastern border passing west of Buffalo, Fredonia, and Tyro, while its western border runs approximately from Yates Center to Toronto, Fall River, Elk Falls, Sedan, and Elgin. To this region the name 'Chautauqua Sandstone Hills' may be here given. The name is already employed somewhat in common usage. These sandstone hills are as characteristic a feature of southeastern Kansas as are the Flint Hills.

"The surface is intersected by many small streams which have deep valleys. The Verdigris river, Fall river, and Elk river cross it, occupying deep channels which are worn to base level in the eastern part of the area. Along the western portion they are still cutting the more persistent ledges. The valleys have narrow flood plains and are walled in by bluffs formed by heavy sandstone protecting the more friable shales beneath.

"The low hills which are the prominent feature of the area are covered with a growth of Jack oaks. The sandy soil is seemingly adapted to their growth, for where the limestone areas are approached the Jack oak timber disappears. Elsewhere in the state other similar sandstone areas have been noted where the forest growths are similar. Such an one is the sandstone hills area west of Thayer and south of Independence along the west side of the Verdigris where the sandstones of the Thayer shales greatly predominate.

"Although the Chautauqua sandstone hills are nowhere very high, the difference in elevation over the entire area scarcely exceeding 250 feet, yet they produce so rugged a surface that traveling is rendered difficult, largely on account of the broken down fragments of sandstone which cover the surface of the hills, and the loose sand which accumulates in the valleys, produced from the disintegration of the sandstones."

The unusual thickening of the Lawrence shales to the south and the extraordinary amount of sand within them are matters of great interest. Each of these conditions implies that here there was a coastal deposit and that a relatively large drainage area was near by to produce such an excessive amount of sand and silt.

This large bed of easily eroded material has strongly affected the topography of the country, not only over the area where the Lawrence shales are exposed, but also further to the west. Being so easily removed by erosion they have been worn away until the general level in western Montgomery and eastern Chautauqua counties is 200 or 300 feet lower than it otherwise

would have been. The extraordinary wearing away of this area has given an unusual steepness of surface to the country lying to the west which is protected from erosion by the heavy beds of flint-bearing limestone, and which therefore is made to stand out as a great row of hills almost mountainous in character on their eastern slopes. Had the Iola or Garnett limestones continued as heavy to the south as they are further north, and had the Lawrence shales been no heavier southward than they are in the vicinity of Yates Center, Le Roy, and Princeton, this great difference in elevation would not now exist, and the eastern slope of the Flint Hills would be little if any more prominent than the eastern slope of the general uplands along the middle line of Kansas.

Coal in the Lawrence Shales.

A large amount of carbonaceous material exists in the Lawrence shales, frequently in the form of well preserved coal and elsewhere in lesser proportion, rendering the shale beds characteristically black. Coal is mined from the Lawrence shales irregularly from Atchison southward through Douglas and Franklin counties to the south side of the state. The coal mines at Atchison probably will ultimately become the most valuable of any in the Lawrence shales. At present, however, the mines which are the most extensively operated are in Franklin county in the vicinity of Pomona and Ransom, from which places large quantities are annually placed upon the local market. Southward in the sandstone areas coal is less abundant, but here and there south of the Neosho river it is frequently found in sufficient quantity to justify mining for local consumption, and elsewhere in lesser deposits which have no commercial value, but which are interesting theoretically because they tell of the general physical conditions under which this great bed of Lawrence shales was formed.

Limestone in the Lawrence Shales.

Here and there throughout the Lawrence shales local limestone beds are found. The most notable of these is a limestone near Lawrence. It lies about 140 feet below the top of

the shales and varies from a mere beginning to 5 or 6 feet in thickness. Just east of Blue Mound it is prominent. Likewise along the Kansas river it may be seen on either side, forming a bluff which gradually rises eastward from Lawrence until it reaches a hight of from 100 to 125 feet above the river. This bluff may be noticed by one passing east from Lawrence on either side of the river, but it is more prominent on the north. Between Lawrence and Tonganoxie or Leavenworth it becomes the most prominent and with the rise of the surface of the limestone eastward, due to the westward dip, an elevation is reached almost as great as that of the top of the terrace at the summit of the Lawrence shales. But this limestone is of little importance stratigraphically because its extension east, west, north, or south is so limited. It cannot be traced westward even to the escarpment capped by the overlying limestone as the surface now is. The line of the remnant is found in the eastern suburbs of Lawrence where it is only 15 or 18 inches thick. Likewise along the foot of the heavy escarpment between Lawrence and Tonganoxie the limestone disappears within half or three-quarters of a mile from the escarpment. Also it fails to have an existence southward, being entirely absent in the many places where deep wells have been drilled south of the Neosho river.

A few other lesser limestones likewise may be noted. Below the one just referred to a less important limestone bed is found which is noticeable almost at the water's edge at Lawrence. Here the south end of the dam crossing the river rests upon this limestone but it cannot be traced for a mile in any direction.

Again west of Lawrence along the south bluff a limestone quite oolitic in character is noticeable from three to five or six miles west of the city. This likewise, as far as is now known, has a very limited extension in every direction.

OREAD LIMESTONES.[25]

First above the Lawrence shales lie two distinct limestone beds separated from each other by a thin bed of shale which at Lawrence is but 15 feet thick. The limestones each vary from 8 to 20 feet in thickness near Lawrence, and elsewhere the variation is even greater. Just west of Lawrence, hardly outside the city limits where a stone quarry has been extensively worked, the lower Oread measures fully 20 feet. At Atchison the upper Oread measures 21 feet, while to the north and northwest, according to the deep well records, the thickness remains about the same. Southwards the general tendency is towards a decrease in thickness of each limestone until the middle part of the state is reached, while still further south there seems to be an increase in thickness until the Oread limestone becomes a prominent character, reaching all the way to the south line of the state.

The line of outcropping of the Oread limestones is practically the same for both the upper and the lower, as the shale between the two is so thin. In fact, beginning at Lawrence and extending northward, one and sometimes two lesser beds of limestone appear between the upper and lower Oread which help to produce the one line of escarpment. In Jefferson county one of these beds, from 2 to 4 feet in thickness, furnishes the unusually good stone which is so extensively wheeled to Lawrence and used for street curbings.

The extraordinary thickness of the underlying Lawrence shales, in connection with the protection furnished by the Oread limestones has resulted in the production of an unusually prominent escarpment along the eastern outcropping of the limestones. This escarpment is the longest and most pronounced, everything considered, of any one known in the state and has been traced from Atchison entirely across the state to the southwest, to Elgin in Chautauqua county. Throughout the greater part of this distance it has been traced in detail and the exact location determined to within a mile or less, but in places

25. Haworth: Kansas University Quarterly, vol. ii, p. 123, Lawrence, 1894.

it has been located for a few miles by observing it from a distance, so that the representation on the accompanying map, Plate VII, may vary from one to three or four miles east or west from where it should be.

In general character the Oread limestones are not particularly different from those found elsewhere. They have a pronounced buff color, with a light greenish blue on freshly broken surfaces, showing that they contain a comparatively large amount of earthy material bearing ferrous oxide which by weathering is oxidized to the ferric oxide state, producing the buff color. They are firm, compact, and fine grained, and highly crystalline in places so that they could be polished almost like marble, but elsewhere are so filled with impurities that upon weathering they assume a slightly porous structure. The Upper Oread limestone carries a large amount of flint, which, upon the weathering of the limestones, produces flint gravels that are scattered extensively over the surface just east of the line of outcropping almost entirely across the state from Atchison to the southwest. No limestone is known in the whole Coal Measures carrying more flint than the upper Oread, excepting the upper member of the Erie system, already described.

The fossils contained in the Oread limestones are numerous and in some cases almost characteristic, the upper one alone furnishing fifty species to Mr. Bennett from a single locality at Lecompton. The following is a partial list, which will serve to illustrate the general faunal characteristics: *Fusulina cylindrica*, two *Bryozoans*, *Fistulipora nodulifera*, *Chætetes* (?), two *Crinoids*, *Archæocidaris* (?), *Cyathaxonia distorta*, *Athyris subtilita*, *Spirifer cameratus*, *Spirifer lineatus*, *Spirifernia kentuckiensis*, *Productus prattenianus*, *Productus symmetricus*, *Productus americanus*, *Productus pertenuis*, *Productus costatus*, *Productus punctatus*, *Productus nebrascensis*, *Productus longispinus*, *Derbya bennetti*, *Derbya broadheadi*, *Meekella striato-costata*, *Syntrialasma cosa*, *Chonetes granulifera*, *Schizodus wheeleri*, *Chænomya leavenworthensis*, *Allorisma subcuneata*, *Allorisma granosa*, *Pinna peracuta*, *Edmondia* (?), *Rhynchonella uta*, *Chænocardia* (?), *Monoptera* (?), *Macrodon* (?), *Aviculopecten* (?), *Bellerophon crassus*, *Bellerophon* (?),

two species of *Nautilidæ*, *Euomphalus rugosus*, *Orthis carbonaria*, *Campophyllum torquium*, *Pleurotomaria*, two species, a branching coral, and other unidentified forms.

LECOMPTON SHALES AND ELGIN SANDSTONE.

First above the Oread limestone lies a shale bed that may be traced entirely across the state and which is heavier and more persistent than any other shale bed between the Oread limestone and the Osage shales. At Lecompton, according to Bennett, it measures nearly 100 feet in thickness. It is prominently represented in the section west of Atchison by Professor Knerr, Plate V, and also by the section, Plate V, Volume I, by Mr. Hall, running west from La Cygne.

There is a wider zone on the surface between the outcropping of the Oread limestone and the first one to the west than there is further west for some distance. This shale bed is persistent from the north side of the state across to the south and may be fairly well differentiated from the lesser ones below. In places it contains much sandstone and elsewhere almost none. Adams suggests that the sandstones within these shales in the southern part of the state be designated as the Elgin sandstone, on account of their extraordinary development around Elgin. It might be well likewise to give a distinct term to the shale bed, for which the name Lecompton shales is offered, as they are well exposed at Lecompton, and as Lecompton is a name which will ever remain prominent in Kansas history.

REMAINING FORMATIONS.

Above the Lecompton shales we have an alternation of shale beds and limestone horizons forming a terrane several hundred feet in thickness. No one of these limestones is specially prominent by itself or has specially important stratigraphic properties. The shale beds separating them likewise are comparatively thin and relatively unimportant. Their thickness varies greatly in different parts of the state and therefore the distance between the lines of outcroppings of the limestones correspondingly varies. In general in the southern part of the state the shale beds

KANSAS RIVER SCENE, LAWRENCE.

(Photographed by Stevens, 1894.)

CHAUTAUQUA SANDSTONE ALONG THE WAKARUSA.

(Photographed by Marcy, 1896.)

OSAGE SHALES AND INCLOSED THIN LIMESTONE, CEDAR FALLS.

(Photographed by Riederer, 1898.)

are thinner, bringing the limestones closer together, and producing thereby a set of terranes or escarpments not very high but close together. On the map, Plate VI, showing the outcropping of the different limestone systems three or more of these limestones are noticed outcropping near together west of the Oread limestone throughout Chautauqua, Elk, and Greenwood counties. The area between Greenwood and Shawnee counties has not been studied in sufficient detail to trace each of these limestones separately.

Northward the shale beds thicken and the limestones correspondingly appear on the surface farther apart. The individual limestones are correspondingly more easily traced and appear in the sections run by Hall and Bennett, as published in Volume I, Plates V and VI, to be more nearly distinct limestones than the same ones seem to be south of Greenwood county.

Doctor Adams's Field Work.

During the summer of 1897 Doctor Adams studied Chautauqua, Elk, and Greenwood counties in considerable detail and prepared that portion of the map, Plate VI, on which the outcroppings of the several limestones are marked. Mr. Bennett, in Volume I, Plate VI, and accompanying description, has given a detailed account of a geologic section along the Kansas river.

The Osage shales have been traced from Topeka to the Neosho river and sufficient work was done between the river and Eureka to justify us in concluding that they also extend into Greenwood county, connecting with the heavy shale bed which is here and there coal-bearing throughout Greenwood, Elk, and Chautauqua counties. We therefore know that these formations extend across the state the same as others lower down.

The result of Adams's work in the south is expressed in the map, Plate VI; in the geologic sections, Plates I and II; and in the following description which is adapted from his field notes for 1897:

Elk Falls Limestone.—'Above the Lecompton shales throughout Greenwood and Chautauqua counties are two well defined

limestone horizons separated from each other by a thin bed of arenaceous shales which here and there develops into well-formed sandstone. The thinness of the shale parting and the persistence of the upper limestone have resulted in the two forming practically the same terrace throughout the greater part of this distance. This terrace is prominent just west of Elk Falls, from which place the limestones are named, from whence it passes southward with many deep sinuosities around the head of Salt creek, North Cana, Middle Cana, and Cedar creek, and leaves the state west of Elgin. It is seen very prominent at Rogers, about five miles west of Sedan.

'Northward from Elk Falls it reaches up Elk river almost to Howard, veers eastward again on the highland beween Elk river and Fall river to the vicinity of Cave Springs, passes up Fall river by the way of Greenwood to within five or six miles of Eureka, then veers eastward on the highland between Fall river and Walnut creek, and again up Walnut creek to near Tonovay, making a line approximately parallel to the Osage escarpment already defined.

'The sandstone between these two limestones is particularly prominent in the vicinity of Cave Springs where both the upper and lower limestones may readily be seen, from between which the sandstone has been worn away, producing numerous recessions and caves. The name Cave Springs originated from such a location and may be used to designate these particular sandstones.

Severy Shales.—'Above the Elk Falls limestone is a bed of shales averaging from 50 to 75 feet in thickness, which, with the protected limestone above, forms a light escarpment that may be traced from a few miles below Eureka to Cedar Valley, forming a line from two to five miles west of the Elk Falls escarpment. This shale bed is, therefore, sufficiently prominent to be recognized in the field and to be of considerable local stratigraphic importance. The town of Severy lies within it and therefore it may be called the Severy shales.

Howard Limestones.—'Above the Severy shales is a thin limestone, persistent from near Eureka to the south line of the state, but which nowhere is more than from 3 to 6 or 8 feet in thickness. In connection with the Severy shales it forms an escarpment as already described and which is readily seen lying a short distance west of the Santa Fe railway from Severy to Moline. South of Moline it bends westward around the upper tributaries of the various drainage channels, finally passing southward to Wauneta, thence southwest almost to Cedar Valley, and back southeast down Cedar creek and out of the state. North of Severy it passes west to Climax, then to within three miles of Eureka, thence above Tonovay two miles, and thence northeastward to beyond the limits of detailed field work.

Osage Shales.—' Succeeding the Howard limestone is a bed of shales producing coal in several places. This seems to be an equivalent to the Osage shales, as it has been traced all the way from Chautauqua county northeast to beyond Topeka.

' The coal is usually found about the middle of the shale bed and has a light limestone overlying it in most places. Mines have been opened at Eureka, near the head of Pawpaw creek; west of Howard, on Bluff creek; west of Moline; at Leeds, near Cedar Valley; and on the state line; but at present the most of these are abandoned. The coal varies considerably in quantity and is usually from 12 to 14 inches in thickness. At Leeds it is the most important. Mining here is usually conducted during the winter months.

Eureka Limestone.—'Above the Osage shales there is a limestone which serves as a protector and assists in the production of a permanent escarpment, reaching from Madison, in northeast Greenwood county, southward by way of Eureka around the heads of Honey creek and Tadpole creek, just west of Climax, between Severy and Piedmont, around the head of Pawpaw creek, to from four to six miles west of Howard, three or four miles west of Moline, by way of Cedar Valley, and around the head of Rock creek to the south line of the state.'

Extracts from Bennett's Kansas River Section.

Having studied the conditions in the southern part of the state let us now turn our attention to the conditions prevailing along the Kansas river. In Volume I, Chapter VI, Mr. Bennett has described the conditions which prevail from Lawrence to a few miles west of Topeka in great detail and has illustrated the same by Plate VI. From this chapter the following quotations are made, while Figure 2 is a reproduction of the part of Plate VI, from Lawrence to Topeka.

Lecompton Limestones.—"Capping the hills around Lecompton is a 5-foot limestone in two layers, which we will provisionally name the 'Fusulina' limestone, not that it alone bears that fossil, but because of the abundance of Fusulina in it. It is the lower of another triple system of limestones, the members of which are separated by a few feet of shale, and which retain this order as far as observed to the west. Above the 'Fusulina' stratum are 5½ feet of clay shales, then 1¼ feet of blue limestone which weathers dark buff like all its associate strata. Above this are 4 feet of shales having a bituminous streak in the middle, then 10 feet of light gray, easily disintegrated limestone. This group may be called the Lecompton limestone, on account of their outcropping being near Lecompton. At Spencer, six miles west of Lecompton, the upper of the series finally disappears below the alluvial soil of the valley.

"The fossils of the Lecompton series merit little attention except the *Fusulina* of the lower bed. In the top of a hill near Lecompton, where the lower member was greatly weathered, this little foraminiferous rhizopod lay in such profusion that it looked as though some farmer had emptied his wheat sack in the soils.

"Passing westward from Lecompton a slight difficulty was encountered in the correct understanding of the strata. The hills around Spencer were so covered with glacial material that the strata were principally concealed. One limestone was visible on a hilltop a mile south of Spencer, and which seems to dip westward and reach a relatively low position at Tecumseh. Two other limestones are also visible at Tecumseh, one of which forms quite a riffle in the river, and the other one of which lies below it and forms a floor to the river for some miles below. The glacial material is so abundant between Tecumseh and Spencer that an error might easily be made in the correlations, but it seems that the section above the Lecompton series is as follows, counting upwards: First the thin layer in the bed of the river below the riffle about 40 feet above the Lecompton system; then 4 feet of shales, and then the riffle rock 3 or 4 feet thick; then 25 feet of buff clay shales with small lenticular bodies of limestone throughout it; and then 2 feet of blue clay shales immediately under the top rock at Spencer above mentioned.

Deer Creek Limestones.—"We now come to what we call the Deer Creek systems, the bottom one of which may be the limestone seen in the top of the hill at

Spencer, and is seen at a few places southeast of Tecumseh. The Deer Creek exposure presents the following section, passing upwards:

"First, 6 feet of fossiliferous unevenly bedded limestone which was overlaid by 10 feet of shales, then a single-bedded limestone 2 feet, then 4 feet of drab and blue shales, and again 4½ feet of limestone. These limestones were scarcely seen excepting in the Deer Creek exposures. They disappear altogether two miles or so east of Topeka. But above them in the tops of the hills, and separated by about 60 feet of slopes, are remnants of the system above, or the Topeka limestones.

"The organic remains were well preserved in the Deer Creek system, and the following genera and species were noted: *Productus altonensis* (?) (might be young of americana) were especially abundant. *Bellerophon crassus* were found here.

Topeka Limestones.—"Coming now to the Topeka limestones, we find a quadruple series. In an exposure a mile east and a mile south of Topeka there is a showing of the upper section of the underlying shales. About 6½ feet below the top of the underlying shales a fairly good building sandstone is reached which is 3 feet thick. The lower limestone of the Topeka system is 6 feet thick, and is blue but weathers dark buff. Above it is a foot and a half of blue shales, then above that 5 feet 8 inches of blue and brown limestone having a cherty layer near the top. Above this comes 2 feet of buff shales, and then again limestone 1½ feet thick, above which are 3 feet of drab shales, which are again capped by 2 feet of limestone. The city of Topeka rests mainly above the cherty bed or second limestone of the series, yet here and there are fragments of the third or thinnest layer in place. The cherty bed has been extensively quarried by the builders of the city in the past and quarries are now being operated near Shunganunga creek in the south part of the city. The Santa Fe and

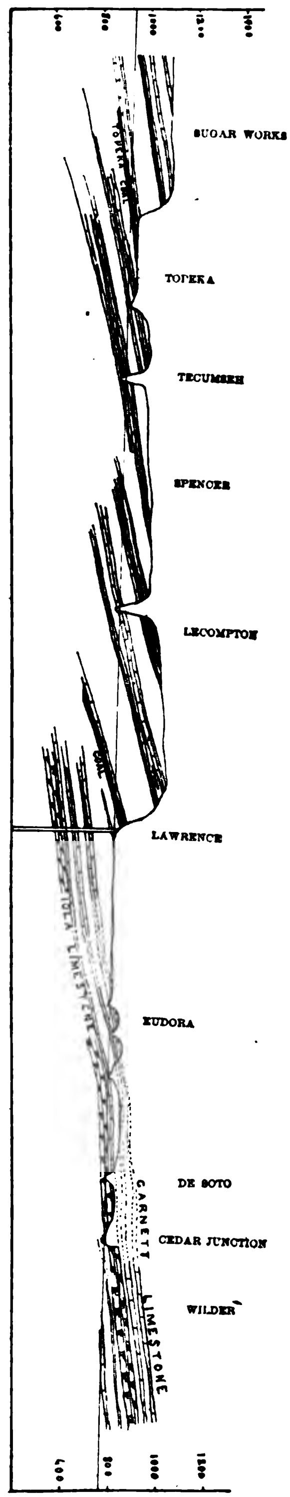


FIGURE 2. Showing succession of strata along the Kansas River from Wilder to Sugar Works. (After Bennett. From Plate VI, Vol. I.)

the Missouri Pacific railroads have made a few exposures in the two upper limestones of the series just south of the city. In the various quarries a good opportunity was given to study the paleontology of the quadruple series. The fossils collected were: *Fusulina cylindrica*, *Fistulipora nodulifera*, *Rhombopora lepidodendroides*, *Chætetes* and a romose unknown form of *Chætetes*, *Archæocidaris* ——, ——, *Chonetes granulifera*, *Productus punctatus*, *Productus longispinus*, *Productus costatus*, *Productus prattenianus*, *Athyris subtilita*, *Spirifer cameratus*, *Streptorhynchus crassus*, *Terebratula bovidens*, *Retzia mormoni*, *Bellerophon carbonarius*.

"The shales above the Topeka limestone could nowhere be accurately measured. At the brick-yard, three miles west of Kansas avenue, in Topeka, 28 feet of the upper part of the shales are exposed, and in a well close by we were told that 20 feet more had been penetrated before reaching the Topeka limestone. This would make them 48 feet thick, which we had good reasons for thinking was about correct. At the top of the shale lies 11 inches of coal, which has been mined in many places just west of Topeka, and which may be called the Topeka coal. Above it lies 2½ feet of clay shales and then 2 feet of argillaceous limestone, then 6 feet more of shale, and again 2 feet of gray limestone. These limestones although thin were persistent for several miles to the west, where they and the underlying coal disappeared under the valley. The only fossils of any importance in this system were *Chonetes granulifera*, *Fusulina cylindrica*, a *Productidæ*, and Crinoid columns."

. . . .

"Four miles west of Topeka a section exposed in a railroad cut shows 26 feet of shales above the limestone system just described, and above them is a hard band of sand rock 2 feet thick which held its place until Lee's creek was reached, a mile and a half farther west. Beyond the creek at the sugar-works it was not seen. At the sugar-works, six miles west of Topeka, the coal and limestones above mentioned were all under the valley. Here the slope to the next limestone above was 91 feet from the Rock Island railway track, all of which seemed to be shales, but the exact thickness of the shales below the track could not be told. A reasonable approximation would put it at 25 feet, making a whole bed of 116 feet.

"At the summit of the last mentioned shale there is a foot of coal, and immediately above it 2½ feet of limestone. . . ."

Extracts from Hall's Osage River Section.

Mr. John G. Hall, at that time a student in the University, prepared Chapter V for Volume I, which report is accompanied by Plate V, showing a geologic section along the Osage river. Mr. Hall, although not a trained geologist, did his work under such supervision and proved himself to be so careful a student that reliance can be placed in his conclusions. It is important to note his section west from Ottawa to Burlingame which forms a line nearly parallel to Bennett's section along the Kansas river,

but about thirty miles to the south. The following quotations are taken from Hall's report, and Figure 3 is an exact reproduction of a portion of his Plate V showing the conditions from Ottawa to Burlingame:

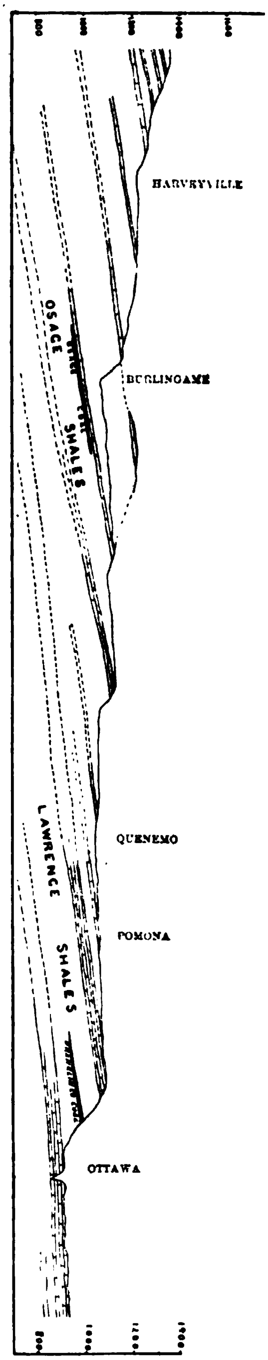
Systems Above the Oread Limestone.—"The first limestone system above the Oread appears ten miles west of Ottawa, and is 4 feet thick, covering a shale bed 50 feet thick. The general appearance of the limestone is much like that of the Oread limestone and would make good building stone. The shales below this limestone are buff in color and are generally soft, and hence yield to the weathering agencies quite readily, but sometimes they turn into a brown sandy shale which is very coarse, instead of being composed of the fine particles that generally make up the shales.

"Following up the river another limestone, No. 2, is reached a mile west of Quenemo, and is 5 feet thick, covering a shale bed of 20 feet. It is composed of two layers of almost equal thickness and is of a grayish yellow color and quite hard. The shale bed has so many thin layers of sandstone, which are made up almost entirely of sand, that it wears away nearly as slowly as the limestones. The layers of silicious sandstone are none of them more than 2 or 3 inches thick, while most of them do not exceed half an inch.

"Six miles to the northwest of Quenemo system No. 3 crops out, which is 10 feet thick, the upper 4 feet of which is brown in color, while the rest is almost white. The whitish portion contains one layer about 1 foot thick which is composed of fossil *Fusulina*, the shells of which are about the size and shape of a medium-sized grain of wheat.

Osage Shales, Coal, and Limestone.—"Six miles southeast of Burlingame system No. 4 crops out, but can be traced only a short distance until it is lost to sight. It is 15 feet thick, and corresponds so closely with the one found under the coal at Burlingame, both in

FIGURE 3. Showing succession of strata along the Osage River from Ottawa to Burlingame. (After Hall. From Plate V, Vol. I.)



thickness and general structure, that there can be little doubt but that it is the same system. It is very soft, and therefore easily worked, but not used much on account of its softness.

"The coal found at Burlingame is from 75 to 90 feet below the surface of the ground, depending on the position of the shaft. There is a broad almost level strip of country extending over nearly the whole of Osage county, underneath which the coal is found. The coal varies in thickness from 18 inches to 3 feet. It is mined at Osage City, Scranton, Burlingame, and Peterton, and formerly was mined at Carbondale, but these mines have not been worked for some time. The whole country is dotted with coal shafts, some of which are worked only for private use, while the majority are worked and the coal put upon the market.

"*Burlingame Limestones.*—Just west of Burlingame, system No. 5 makes its appearance. It is 8 feet thick, is brown in color, shelly in character, and covers the third and last heavy bed of shales in this section. The shale bed is 150 or 200 feet thick, and throughout it are found thin beds of limestone which tend to cause the shales to resist erosion. Here, as with all other thick beds of shale, are a number of isolated mounds which are covered with limestone that corresponds in general so closely with that found on the main bluffs one cannot help believing they are the same system. These mounds are most numerous to the north of Burlingame, and differ in height from 50 to 125 feet. The most important one is about two miles from Burlingame and is 85 feet high, and covers an area of almost a square mile."

CORRELATION OF SECTIONS MADE BY ADAMS, BENNETT, AND HALL.

From the foregoing quotations and illustrations it will be seen that there is a close resemblance between the Kansas river section of Bennett and the Osage river section of Hall, and that there are along each section three principal limestone systems above the Oread limestone and below the Osage coal and shales. As the sections are but thirty miles apart and the similarity so great between them there can be no reason for doubting that they are the same.

During 1897 the Osage coals and shales were traced southward by Bennett to Lebo where coal has been mined, leaving no doubt but that the coals here are the same as at Osage City, Burlingame, Scranton, etc. Throughout its whole distance the coal lies to the east and below the heavy escarpment produced, as described by Hall and quoted above, by the Burlingame shales and limestones. This same escarpment passes to the southwest across the Neosho, occupying the hills just west of Madison, Hamilton, Utopia, and becomes the escarpment at

Eureka which is protected by the Eureka limestone as described by Adams. The Osage limestone of Hall thins out and becomes unimportant, so that it cannot be used as a division line between the shales. The Osage shales, therefore, may be considered to extend upwards to the Burlingame limestone, including what Hall called the Burlingame shales. From both the lithologic and stratigraphic standpoint this is a natural classification, and would have been made in Volume I had we then possessed the necessary information.

Having correlated the Burlingame limestone of Hall with the Eureka limestone of Adams priority requires that the former name stand.

As there are practically the same number of limestone and shale beds between the Oread limestone and the Burlingame limestone all the way across the state, there can be no reasonable doubt of their connection; therefore, the nomenclature of Bennett in his Kansas river section, having priority, should stand. It has been followed in the general section of the Coal Measures in this volume, Plate VI. As the shales between the Lecompton limestone and the Deer Creek limestone have been named the "Tecumseh" shales by Beede[26] that name is here adopted, as is also his name "Calhoun" shales for those first above the Deer Creek limestone.

GENERAL RESUMÉ OF COAL MEASURE STRATIGRAPHY.

Having given in considerable detail the location and general character of each of the principal formations in the Coal Measures of Kansas a few general remarks applicable to the whole area may be of service in forming a correct idea of the Coal Measures of the state. From the detailed descriptions it will be seen that the Kansas Coal Measures differ in many respects from those of any adjoining states, at least so far as descriptions of the others have been published. The one great difference which has impressed itself upon the minds of all who have recently worked in this field is that the division line between the coastal and non-coastal formations does not exist here as it is re-

26. Beede, J. W.: Trans. Kan. Acad. Sci., vol. xv, Topeka, 1896.

ported to exist in Iowa and Missouri. Let us first consider how the coastal lines have migrated during Coal Measure time.

We find evidence of an emergence at the close of the Mississippian period sufficiently extended to bring into dry land form parts of Arkansas, Indian Territory, Kansas, Missouri, and Iowa, but how much of them it is difficult to say. The extent of the surface erosion resulting therefrom has already been described, and it was seen that there is little evidence favoring the view of extensive erosion west of the eastern limits of the Coal Measures as at present found. If, during this period, there was heavy erosion eastward, the sediment produced by such erosion must have been carried oceanward and deposited some place to the west and would be characterized by the nature of the materials eroded. It is true the subsurface conditions lying to the west have been studied but imperfectly, as they necessarily must be so long as the overlying strata conceal them. It is difficult to understand how an extensive erosion of the Mississippian limestone with its heavy flint beds as now known to exist on the surface could have taken place without the detrital material from the flint being carried oceanward and deposited as conglomerates. The surface of southwest Missouri and northwest Arkansas is now covered with gravel beds retained as residual products as the flint-bearing limestones have been eroded. These gravels are carried downwards in our streams for great distances, some of them even for hundreds of miles. If there was corresponding erosion between Subcarboniferous and Coal Measure times, it is difficult to understand why similar gravels were not carried oceanward at that period or left on the surface then existing to form conglomerates and gravel beds at the base of the Coal Measures as they now lie. Such gravel beds have not been found although dozens of deep wells have gone through the Coal Measures and for some distance into the Mississippian limestone. This negative evidence is not conclusive, but it must be admitted that it has a value, and so far as it goes tends to minimize the surface erosion between Subcarboniferous and Coal Measure times.

We may therefore conclude that at the beginning of Coal

Measure time the coastal line lay to the eastward of the present eastern limits of the Coal Measures. How far, is the merest conjecture. At that time the gravel beds and conglomerates, already alluded to, probably were formed and have since been entirely destroyed by erosion, a portion of the gravel from which may now constitute the gravel beds so abundant in Arkansas and Missouri. Such gravel beds necessarily were formed in narrow belts along the ocean and therefore later when the Coal Measures were lifted to the surface and were eroded their easternmost extension necessarily would be eroded first and the narrow gravel beds destroyed. This view limits the westward recession of the coastal line and implies that previous to Lower Coal Measure time it had passed but little farther west than the present eastern limits of the Coal Measures.

The materials from which the Cherokee shales were made seem to have come from the east, and were detrital obtained from the breaking down of ordinary terranes. No feldspathic granules or boulders have been found anywhere within them, no micaceous or other fragments other than that ordinarily found in ordinary sandstones and shales. The great extent of the Cherokee shales north and south implies a like condition over a wide area. It is one of the peculiar and interesting facts throughout all America that the Coal Measures proper are composed of so nearly the same kinds of material. The Coal Measures of the Appalachians, however, and particularly the lower strata, contain many more conglomerates than are found elsewhere, and correspondingly show a different series of physical conditions which influenced their formation. But from Iowa to Arkansas throughout the whole distance the Coal Measures west of the Mississippi seem to be essentially the same throughout their lower formations, and seem to be sediments accumulated from sluggish streams draining a land area with but slight elevations, or deposited far out at ocean where none of the coarsest material could be carried.

At the close of the period during which the Cherokes shales were formed an oscillation of elevations must have carried the

shore line farther to the east, as ocean water overspread the shales and limestones were formed. It is interesting to note that the uppermost parts of the Cherokee shales are so rich in carbon, producing the Fort Scott coal and the unusually black carbonaceous shales both below and above the coal beds. The first limestone formed is the Fort Scott cement rock which, as already seen, is different in its physical properties from any other rock known in the state. It seems to have been formed in a quiet ocean where a continual supply of the most finely ground shell detritus was intermingled with the finest silt.

Immediately at the close of the cement rock a thin bed of shale was formed which, like the first below, is characterized by an unusually heavy amount of carbonaceous material. Then follows the Upper Oswego limestone, or the Fort Scott coral rock as it is sometimes called. Here the ordinary oceanic conditions prevailed to a greater degee. Animal life was exceedingly abundant in the other localities where the limestone is now found, as is witnessed by the myriads of fossils it bears, and especially by the particularly large coral masses found from Oswego to Fort Scott and beyond, which plainly have never been moved from their places of origin. While the Cherokee shales gradually grow thinner to the west, these limestones on the contrary gradually thicken in that direction and we may reasonably suppose that the portions which have been removed by erosion to the east were thinner than those left to the west, that in an easterly direction they were formed in thinner beds, until, as the shore line was reached, they entirely disappeared. The great lateral extent of the Oswego limestones from north to south and from east to west indicates a similarity of conditions over hundreds of miles in extent.

The change from limestone to shale formation seems to have been sudden, for the upper surface of the Oswego limestone is as clearly defined as the lower. The conditions during the formation of the Labette shales were not so uniform as prevailed while the Cherokee shales were forming. We find more sandstone in places, and less elsewhere, the variations being greater and more marked.

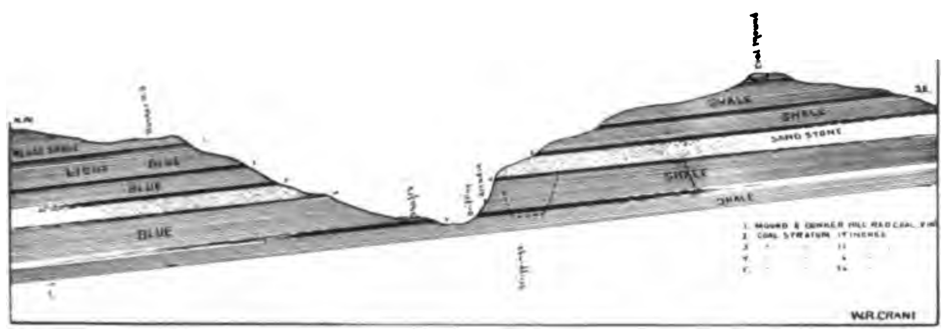
While the Pawnee limestone was forming the conditions were more variable than during the formation of the Oswego limestones. The Pawnee does not have so great a northern extension, yet in the vicinity of Fort Scott they are thicker and heavier than the Oswego limestones at any place. It would seem that the limestone forming conditions did not prevail over the whole area in southeastern Kansas, or rather that they prevailed in a remarkable degree in the vicinity of Fort Scott and westward, while both south and north conditions were less favorable for the accumulation of limestone material. This irregularity of conditions is more marked than that found at any lower level in the Coal Measures of the state.

During the Pleasanton shale period the general physical conditions of the Cherokee shale period were repeated. The strong similarity between the general properties of the Pleasanton shales and the Cherokee shales is remarkable. No one could distinguish between them from any of their physical characters, excepting that the amount of coal in the Cherokee shales in places is a little greater than any that has yet been discovered in the Pleasanton shales. The large deposits of flagging stone are the same in the two. The heavy beds and thick layers of sandstone likewise are the same in the two. The abundance of ripple marks and wave marks is the same for the two. The variations from argillaceous to arenaceous and then to carbonaceous are the same for the two. If the physical properties of the one imply that they were produced near the coast subject to the variations of coastal deposits, then the same is true of the other. The great abundance of broad thin flags in the vicinity of Gilfillan, Redfield, and Bandera is a repetition of similar flags in the lower part of the Cherokee shales in the vicinity of Crestline and to the southeast of Columbus, while heavy beds of sandstone at the very summit of the Pleasanton shales at Boicourt and La Cygne are a repetition of the heavy layers of sandstone in the Columbus sandstone area. The great extent of the shales north and south and east and west is likewise similar to that of the Cherokee shales.

Here, however, there is a difference. The Pleasanton shales

are thickest midway of the state, gradually growing thinner to the north, while the Altamont limestone bisects them to the south and even with this addition of limestone the sum total of the Lower and Upper Pleasanton shales and the Altamont limestone combined shows no greater thickness than the shales alone do in the vicinity of Boicourt and La Cygne. This sagging, so to speak, of the middle line of the state, with the filling in of the detrital material to produce the shales, and the absence of the Altamont limestone parting recognized farther south, implies a rapid accumulation of shale forming material and probably a proximity to a rapid drainage of the little continent lying to the southeast.

At the close of the Pleasanton shales period a great difference in the physical conditions throughout eastern Kansas was produced. Oscillations rapidly occurred resulting in a series of conditions favorable to limestone production. The heavy beds of Erie limestone resulted, which in many places aggregate more than 100 feet. Here again the conditions were not uniform through eastern Kansas. The center of the limestone formations seems to havo been westward from Fort Scott, while both north and south from this position the conditions were not quite so favorable, and the limestones which resulted were correspondingly lighter. This is particularly true in the south where a series of conditions seems to have prevailed which are of the greatest importance. The limestone layers of the Erie limestone gradually grow thinner and the shale partings gradually grow thicker until we have the great series of the Mound Valley and Cherryvale shales separating the three members of the Erie limestone by an aggregate of about 200 feet. This decrease in the thickness of the limestone southward and the corresponding increase in the thickness of the shale beds can best be understood by assuming that in some way there was an unusually large amount of sediment brought in from the south. The coastal lines probably veered far to the southwest, producing dry land to the southwest in the Indian territory, so that the drainage was to the northwest or probably more nearly to the north throughout the greater part of this period, a condition



SECTION THROUGH ARCADIA.

which, although reversed later, again obtained during the period of the formation of the Lawrence shales. While the uppermost member, or the Independence limestone, was being formed the conditions were reversed. The Independence limestone is rapidly thickened from only a few feet at Cherryvale to thirty or more feet at Independence, ten miles away, showing that here the conditions were most favorable for the prolific growth of marine invertebrates and the accumulation of limestone forming debris. Likewise the deep wells further to the west at Neodesha and Howard show that the heavy Independence limestone increases in thickness even that far away.

The area, in other words, where the Erie limestones are least in quantity and where the shale partings are the greatest is in eastern Montgomery and northwestern Labette counties. The dry land area furnishing the sediments for these heavy beds of shale must consequently have lain to the south in the Indian Territory and the coastal lines during this period must have reached much farther to the southwest and west than at any previous time.

The Thayer shales which overlie the Erie limestones tell an interesting story of the physical conditions existing during their formation. Here we have a great shale bed which thickens to the south to beyond the southern limits of the state. They are more than 200 feet thick at Table Mound and along the heavy escarpment to the west of Independence, from which locality they gradually grow thinner to the north until within Linn county and Miami county and farther to the north through Johnson and Wyandotte counties they have almost lost their identity. This great thickening of the Thayer shales to the southwest again strongly indicates the proximity of a drainage area which was furnishing the unusual amount of material for shale production. The large quantities of sandstone within the Thayer shales tells the same story. This sand mass must have been formed near the shore and for their existence in the positions they occupy the existence of a heavy drainage from the south and southeast was a necessity.

Thus far in our history throughout the whole time subse-

quent to the Pawnee limestone formation the conditions have favored the great thickening of all the shale deposits to the south and southwest, while throughout the same period the limestones in general have been heavier to the north and northwest, a combination of conditions which implies that the great oceanic area lay to the north and northwest and the land areas to the south and southeast. The westward veering of the coastal line immediately at the close of the Pawnee limestone period is most marked and most important to the student of inter-Coal Measure geography.

With the ushering in of the period during which the Iola limestone was formed the conditions were practically the same as those just described. Along the southern line of the state where the Iola limestone outcrops it is relatively unimportant. The great bed of Thayer shales beneath with its easily eroded condition has caused erosion to wear away the Iola limestone to the west. This is particularly true in Wilson county where the limestone has been worn back, forming an embayment twenty miles further northwest than the position it should occupy as indicated by the normal direction of the outcropping of the Iola limestone. But the great thickening westward of the Iola limestone, as shown by the Howard well, the Toronto well, the Elk Falls well, and other deep wells to the northwest, shows that further back to the northwest, or further oceanward, the conditions were more favorable, and the limestone was formed to a much greater thickness. These properties of the Iola limestone similarly substantiate and confirm the views already expressed, that the coastal lines had migrated westward, and that the areas over which limestone forming conditions prevailed to the greatest perfection were further westward.

At the close of the formation of the Iola limestone the conditions so prominent were reversed and the overlying shales; the Lane shales, are gradually thickened to the north. In fact southward the Lane shales become thinner until south of the Neosho river they are scarcely discernible. Well records to the west along the southern part of the state show that the same conditions existed there. The Howard well and the Toronto

well show less than half the amount of Lane shales that is found to the northeast. This change of conditions must have been brought about by an elevation of the land area northward so that erosion was more rapid and debris more abundant opposite Garnett and Lane and Osawatomie than elsewhere.

The debris of which the Lane shales and the included sandstones are formed does not imply a rapidly eroding continent, but rather they are composed of the finer materials which have come from a continent of but slight elevation, and with drainage streams of mild velocities, similar to the conditions which must have prevailed throughout the formation of the shales lower down.

This excessive shale formation to the north lasted but a short time, for during the Garnett limestone period conditions were more favorable for the production of heavy limestones northward than they were southward. The Garnett limestones are more pronounced and are much heavier along the Kansas river and south in the vicinity of Lane than they are along the southern line of the state. In fact southward from the Neosho river they can scarcely be traced on the surface, due partly to the thinness of the Lane shales and largely to their own unimportance.

Throughout the whole period from the Oswego limestone to the close of the Iola formation there was a general thickening of strata to the south and southwest. But here with the Lane shales and the Garnett limestone there was a corresponding thickening to the north which resulted in leveling up the conditions to a great extent ready for the Lawrence shales to be formed.

In some respects the Lawrence shales are the most interesting formations in the whole Coal Measures. Being heavy to the north in the vicinity of the Kansas river, where they are fully 300 feet thick, growing thinner southward to the middle of the state, and then rapidly thickening beyond to a thickness of more than 800 feet along the southern line, they represent a series of conditions favorable for the formation of shales and sandstones unsurpassed in the whole of Coal Measure time.

The unusually large amount of sandstone irregularly scattered through them implies that the eastern borders of the shales as now exposed were not far removed from shore lines during their formation. This is particularly true on the south side of the Neosho river where the Chautauqua sandstone reached such enormous proportions, almost to the utter exclusion of argillaceous materials of any kind.

It would seem that the coastal lines veered far to the west again and that the dry land area was lifted unusually high, producing an unusually rapid erosion with the production of vast quantities of sand, while the finer and lighter silts were carried beyond to the northwest. It is interesting here to note that the record of the Topeka well, and more emphatically the record of the McFarland well, elsewhere published in this volume, shows an excessive amount of shale with a correspondingly light amount of sandstone and limestone. It is not unreasonable to suppose that the great quantities of sand constituting the Chautauqua sandstones and the corresponding sandstones farther north in the vicinity of Ottawa and Lawrence and Leavenworth were simply the shore deposits, the finer sediments accompanying which were carried farther oceanward and formed the heavy shale beds passed through by the McFarland well.

The great abundance of ripple marks and wave marks in the sandstones of the Lawrence shales, from the south side of the state to the north, markings which not only surpass anything known in Kansas but probably equaling any found anywhere in the Mississippi valley, confirm the above view.

From the Oread limestone upwards to the Osage shales nothing of special importance exists, but the Osage shales are important for many reasons. The outcropping of these shales is about 120 miles west of the eastern limits of the lower part of the Cherokee shales as they now exist. The vertical distance of the shales between the bottom of the Osage shales and the bottom of the Cherokee shales is more than 2000 feet, as is shown by the deep wells at Toronto and other points, while the aggregate distance obtained by adding the thickness of the surface outcroppings is about the same, the decrease in the thickness of

the shales being compensated by the increase in the thickness of the limestones.

The character of the Osage shales with their numerous sandstones and coal beds leaves no room for doubt but that the portions of them now exposed near the surface were formed near the shore. The argillaceous and arenaceous limestones which occasionally are found within the shales tell the same story. Many of them have reptilian footprints within, showing conclusively that they were formed under such conditions that the air-breathing animals of the time frequented the marshes and swamps in which the deposits were accumulated. As stated in Volume I, page 162, "Years ago Professor Mudge[27] discovered many reptilian tracks in the shelly limestones at the quarries near Osage City. He purchased two car-loads or more of the limestones on account of their carrying so many tracks. He shipped a large portion of them to Yale University from which Professor Marsh[28] has recently identified them as being the tracks of *Monopus caudatus* and four or five other species."

The Osage shales in their entirety form a deposit fully 200 feet thick which extends across the state from the south line to the north, and probably for many miles beyond. They represent in their aggregate as conclusive evidence of their having been formed in coastal waters as did any of the Lower Coal Measure shales. The coastal lines therefore must have migrated westward in the aggregate fully 100 or 150 miles from the beginning of Coal Measure time to the close of the Osage shales time.

The position of the outcropping of the several formations in the Kansas Coal Measures is interesting. Of course these lines are determined in their position largely by recent erosion which, in turn, is due principally to two factors, the nature of the formations eroded and the conditions of surface elevation and consequent steepness of surface incline. The former condition is dependent entirely upon physical conditions prevailing at the time when the formations were produced, the latter upon the

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27. American Journal of Science [3], vol. vi, New Haven, 1873.
28. American Journal of Science [3], vol. xlviii, pp. 81-84, New Haven, 1894.

sum total of orographic movements during subsequent geologic time.

According to the geologic maps of Missouri the eastern limit of the Coal Measures trends northeast and southwest in the ratio of 1.4 mile north to 1 mile east. The outcropping of the Oswego limestone in Kansas is a similar ratio of 2 to 1; that is, northward it bears 2 miles north to 1 mile east. The outcropping of the Erie limestone is similar with a ratio of 2 to 1, as is also the outcropping of the Iola. The Oread limestone veers a little more north with a ratio of 2.1 to 1, while the Eureka limestone at the top of the Osage shales has a direction of north and east at a ratio of 3 to 1. It will be seen that the outcroppings of these several limestone systems and likewise of the intermediate shales is remarkably regular upon the general average. Were shorter distances measured, so that the lesser variations could be determined, it would be found that they were considerable, for wherever a shale bed thickens the tendency is for the overlying limestone to recede farther to the west. In general, however, it is seen that the upper members of the Coal Measures have a tendency to approach a more nearly north and south line in their outcroppings. Were similar investigations carried higher into the Wabaunsee formation of Prosser and into the Permian it would be found that the line of outcropping approaches still closer to the north and south direction, due, without doubt, in the main, to the thickening of the Permian limestones in the south, giving them a greater resistance to erosion, and to the thickening of the inter-bedded shales to the north, giving them less resistance to erosion. This is the main feature in the production of the Flint Hills, an area in the southern part of the state which maintains an unusually high elevation with a very abrupt descent on the east. Had the several shale beds from the Mound Valley shales up to and including the Lawrence shales been thinner on the south this variation in the direction of the lines of outcropping, and likewise the unusual steepness on the eastern side of the Flint Hills, probably would have been avoided.

COMPARISON OF KANSAS COAL MEASURES WITH COAL MEASURES OF MISSOURI AND IOWA.

It is impossible to make a detailed comparison of the stratigraphy of the Kansas Coal Measures with those of either Missouri or Iowa on the north, or of the Indian Territory on the south, on account of a lack of available detailed stratigraphic information outside of Kansas. There is a comparatively extensive literature on both the Missouri and the Iowa Coal Measures. But the student of stratigraphy who is searching after details of a definite character to use as above mentioned will be disappointed. No maps or charts are available showing the exact lines of outcroppings of limestone systems in the Coal Measures of either state.[29]

The nearest approach to this for Missouri is the physiographic map by Marbut, Plate II, in Volume X of the Missouri Geological Survey. Marbut's Henrietta escarpment crosses from Kansas into Missouri just north of the Osage river. He says it is "formed by the outcropping of the Henrietta limestones of the Lower Coal Measures." Keyes[30] says that this limestone corresponds to the Pawnee and Oswego limestones of Kansas. But the bluffs on the north of the Osage at the state line are capped by the Erie limestone, the Pawnee disappearing some miles to the south. It is not known whether Marbut and Keyes were mistaken in their identification of the limestones capping the bluffs north of the Osage river at the state line, or whether they meant to place the Erie limestone in the Lower Coal Measures. Keyes, however, is wrong in saying that these limestones correspond to the Pawnee and Oswego.

A strange feature of this Henrietta escarpment is that in Missouri, according to Marbut's map, it veers eastward, passing entirely across the Lower Coal Measures, and connects with the Mississippian outcropping in southwestern Pettis county, a

29. Since the above was written the writer has received, through the kindness of Mr. H. Foster Bain, a proof copy of Prof. Colvin's geological map of Iowa, for 1898, on which the line between the Des Moines and Missourian is represented for Iowa.

30. Keyes, Dr. C. R.: Proc. Ia. Acad. Sci., vol. iv, p. 23, Des Moines, 1897.

condition which is entirely different from anything known in Kansas. With such conditions it is evidently quite unsafe to use this escarpment in stratigraphic correlations.

Marbut's Bethany escarpment, it would seem, corresponds in a general way with the outcropping of the Iola limestone, which crosses from Kansas into Missouri at the northeast corner of Miami county, Kansas, or about the middle of Cass county, Missouri. The low ground produced by the Blue river carries an outcropping line down to Kansas City, but probably the eastern limit of the Iola reaches eastward into Missouri, as is represented by the Bethany escarpment.

The heavy and prominent escarpment produced by the Lawrence shales and the Oread limestone, which is the greatest escarpment in Kansas, seems to have disappeared in Missouri, although it is very pronounced at Leavenworth. Neither do any of the superior Kansas escarpments seem to appear in north Missouri, judging from Marbut's description of the Lathrop plain and the Marysville lowlands in northwest Missouri. It is quite probable that the northward thinning of some of the Kansas shale beds and the protection afforded Missouri by the mantle of glacial material are principally responsible for this difference of physiographic features. The thinning of the Thayer shales in the vicinity of Paola has brought the Iola limestone down so close to the Erie that the escarpment here is not so prominent as it is farther southwest. Should this thinning of the Thayer shales be continued into Missouri it would bring the Iola down so low that this escarpment would ultimately coalesce with the Erie escarpment. Marbut speaks of the Bethany escarpment at the state line being indistinct but becoming more prominent beyond. The above is probably the explanation for such a condition.

If the Kansas terranes at present cannot be traced northward across the state of Missouri with certainty it is much less possible to correlate them in any definite way with the Iowa Coal Measures. Keyes[31] has divided the Iowa Coal Measures into

31. Keyes, Dr. C. R.: Iowa Geological Survey, vol. i, p 85, Des Moines, 1892.

the Des Moines and the Missouri formations, the division being based upon lithologic properties. He says:[32]

"In considering the Coal Measures as a whole, two tolerably distinct classes of sediments are readily recognized: (1) the marginal or coastal deposits, and (2) the beds laid down in the more open sea.

"These two categories are sharply contrasted lithologically, stratigraphically, and faunally. The first is characterized by the rocks being predominately clay shales and sandstones, with practically no limestones. The individual beds have usually a very limited extent, and replace one another in rapid succession, both laterally and vertically. The sandstones often form great lenticular masses, sometimes deeply channeled on the upper surface, the excavations being filled with Coal Measure clays. These and many other phenomena attest a constantly shifting shore line and shallow waters. The fossils contained are nearly all brackish water forms or shore species. Remains of pelagic organisms are not numerous.

"On the other hand, the second class above mentioned is made up largely of calcareous shales, with heavy beds of limestone. The layers are evenly bedded, and extend over considerable distances. The faunas are chiefly composed of strictly open sea forms.

"As the conditions of deposition were evidently those of a slowly sinking shore, the marginal deposits as a whole practically underlie the deep sea formations, the former being regarded as the Lower Coal Measures and the latter as the Upper Coal Measures. At the same time it must be remembered that this does not necessarily imply that the 'lower' measures are to be considered as much older than the 'upper,' but rather that along the great and successive planes of sedimentation different beds of the upper and lower divisions were laid down contemporaneously.

"While the general divisions of the Coal Measures may be readily recognized, it does not seem advisable to draw an exact line of demarkation between the two formations until the evidence of the faunal studies already begun has been fully taken into consideration and a comparison of the different methods of solving the problem is made.

"With this idea of the Coal Measures of the interior basin, the limits of the two formations in Iowa assume somewhat different lines of separation from those which have been commonly recognized.

"It is proposed, therefore, to divide the 'Upper' Carboniferous, or Pennsylvanian series, into:

"(2) The Missouri Stage.

"(1) The Des Moines Stage.

"*The Des Moines formation* represents the lower Coal Measures, or the marginal deposits of the upper Carboniferous. It takes its name from the Des Moines river, which flows for more than 200 miles directly through the beds of this terrane. It extends into Missouri, and follows the northern and western boundaries of the Ozark uplift into Kansas and Indian Territory.

"*The Missouri terrane* corresponds essentially with the 'upper' Coal Measures, representing the more strictly marine beds. It is the formation typically

32. Loc. cit., pp. 84, 85.

developed in the northwestern part of Missouri. The Missouri river also winds its way for more than 400 miles through the beds of this stage, exposing numberless fine sections on both sides of the stream throughout the entire distance."

In subsequent reports of the Iowa Survey little that is more definite as to boundaries of terranes has been given. In Volume III, Prof. J. L. Tilton, in describing a cross section from Winterset to Ford, publishes a chart from which it would appear that at about one-fourth of the distance from Bevington to Winterset a heavy limestone appears, reaching westward to beyond the limits of the chart. In speaking of this limestone he says, page 138:

"If, along the line of the general section, there is encountered a heavy limestone formation whose outcrop can be readily traced northwestward into Guthrie county and southward into Missouri, connecting with a very similar limestone which has been recognized near the northern boundary of the state, a clear and natural line of demarkation is obtained for separating the Iowa Coal Measure area into two distinct districts, one, made up mostly of shore or swamp formation in which coal was abundantly formed (Des Moines terrane), and the other composed chiefly of more strictly marine beds (Missouri terrane). This is the first important limestone above those of the great Carboniferous basement."

Later in Volume V, 1895, page 23, Tilton says:

"In the cross sections along Middle and South rivers it will be seen that the limestone of the Missouri stage does not change into shale as would be true if the 'lower' Coal Measures (Des Moines stage) were the shore equivalents of the present exposures of the Missouri limestone. While it is undoubtedly true the present exposure of the Missouri limestone did have a shore equivalent of shale, when the limestone was deposited, that old shore equivalent has been eroded. The shales of the present Des Moines formation are now continued underneath the limestone of the Missouri stage."

But where this division line between the Des Moines and the Missourian would fall in Kansas is hard to determine. From the descriptions given in different places by the Iowa and Missouri geologists it would seem that it might be anywhere from the Oswego limestone up to the Iola. Tilton's description and chart for Iowa, Volumes III and V, seem to put it at the Oswego, while Keyes and Marbut as already seen in their location of the Henrietta escarpment and the Bethany escarpment, class the Erie in the Lower Coal Measures, and appear to make the base of their Bethany limestone correspond to the base of the Iola, although elsewhere Keyes expresses different views.

It seems that after the heavy deposits of the Cherokee shales and corresponding formations were made throughout Missouri and Iowa, whatever they may be, conditions for a time were more favorable for the deposition of limestones, and that a large amount of limestone was produced. But how many of these limestone horizons are individually continuous from the south line of Kansas through to central Iowa can be determined only by the most detailed field work in actually tracing the outcroppings of the individual horizons. The succeeding heavy shale and sandstone formations, so prominent in Kansas, seem to have no equivalents in Iowa. Our heavy Thayer shales and sandstones of marginal origin, our Lawrence shales with the included Chautauqua sandstones, the heaviest shales in the state and the ones showing the strongest indications of coastal origin, and the heavy and interesting Osage shales, all seem to have lost their significance and importance in Iowa, or to have been so covered up by the glacial deposits and the Cretaceous formations, that they have not been recognized. Everything considered, it would seem advisable to be cautious about attempting exact correlations of a detailed character over so wide a territory. Presumptions may prove to be correct, but they should be held only as working hypotheses until verified in the field. For the present, therefore, it seems desirable to retain the correlations as we know they exist in Kansas and refer to them only as a probability in the territory beyond.

THICKNESS OF THE KANSAS COAL MEASURES.

This report is confined to such portions of the Kansas Coal Measures as lie below the summit of the Osage shales. The Wabaunsee formation of Prosser, occupying a position between the summit of the Osage shales and the Cottonwood limestone, which Prosser has made the summit of the Coal Measures, will measure approximately 500 feet. In Volume I an estimate was made of the thickness of the whole Coal Measures and a chart, Plate XXII, was published showing the relative distribution of the different kinds of rocks composing them. At the close of this season's work, after much of the ground has been gone over and

more detailed examinations made, another estimate has been made and Plate VI is a diagrammatic representation of this estimate. We now estimate the total thickness of the Coal Measures from the top of the Osage shales to the bottom of the Cherokee shales at 2,358 feet, with the different kinds of rock distributed as shown in the diagram. Of this amount it is found that limestone constitutes about 525 feet, and shale and sandstone combined 1,825 feet. The ratio, therefore, of limestone to the whole thickness is 1 to 4.5 nearly, or of limestone to shale and sandstone, 1 to 3.5.

It should be understood in considering this statement that the above estimates are made for what seems to be the average for the whole eastern part of the state. The different individual formations vary so in thickness from place to place that perhaps no one locality could be found where the conditions would correspond exactly to those just given. For example, at La Harpe the bottom of the Iola limestone is a little less than 1,000 feet above the bottom of the Cherokee shales, but the Thayer shales, Cherryvale shales, and others, thicken so much to the south that the distance from the bottom of the Cherokee shales to the bottom of the Iola limestone is greatly increased. The Neodesha well reached the bottom of the Cherokee shales at 1,063 feet, although it started fully 200 feet below the bottom of the Iola limestone. West of Independence different wells have been put down 1,100 feet or more without reaching the bottom of the Cherokee shales, although they started 200 feet below the bottom of the Iola limestone. It is probable that the distance between the Mississippian limestone and the Iola limestone where the latter crosses the south line of the state is fully 1,400 feet, while west from Fort Scott it is not exceeding 950, and further north it is probably less. The varying thickness for other formations would make a variation for particular localities not exhibited in the general section as above given. But on the whole it may confidently be stated that these general figures are about as nearly correct as can be given. The redeterminations of the thicknesses of various formations since the publication of Volume I have not materially modified the results.

DIVISIONS OF THE KANSAS COAL MEASURES.

In Volume I it was suggested that the Kansas Coal Measures be divided into two divisions, the Lower and Upper, with the summit of the Pleasanton shales as the division line. Subsequent investigation has not materially altered this idea. For reasons therein expressed the summit of the Pleasanton shales is a natural division line between the beds below and those above. However, it is not the only natural division line which may be found. The Lawrence shales have proved to be so permanent and stand out so clearly separate from the formations either above or below that they, likewise, form a permanent natural division line between the formations below and above. In fact they are distinct lithologically and stratigraphically from those either above or below. Likewise the Osage shales form a tolerably distinct demarkation from the strata above or below.

There is a question as to how great an extent convenience would require divisions to be made. Prosser has already proposed the name Wabaunsee for all the Kansas Coal Measure beds lying above the Osage shales, and has subdivided the Permian in a similar manner, giving similar names to their divisions composed of different beds of limestones and shales. With a thickness of nearly 3,000 feet of Coal Measures in Kansas it is clearly evident that for many reasons other subdivisions might be convenient.

The older custom of many geologists in dividing the Coal Measures into the Lower and the Upper, or Lower, Middle, and Upper might serve the purpose here, but with these divisions it would be somewhat difficult to decide where the division lines should be made between the Middle and Upper. Further, with such a method it would be desirable at least to attempt a correlation of the Lower, Middle and Upper divisions with those formerly proposed in other states. Such a correlation would be difficult, and the attempt hazardous if not dangerous on account of the lack of detailed stratigraphic knowledge between Kansas and other localities. Three general divisions, however,

might be made, using the Lower Coal Measures as already outlined, and allowing the upper surface of the Lawrence shales to mark the division between the Middle and the Upper. Almost equally strong argument, however, could be used to show the desirability of placing the division line between the Middle and the Upper with the Osage shales, placing all the non-coal bearing strata in the Upper division. Not being able, therefore, satisfactorily to use the older terms on account of the inability to correlate these three divisions with those located elsewhere, it is thought best to retain the division of Lower and Upper as previously used, and to subdivide each of them to whatever extent seems desirable. Accordingly the following scheme is suggested which may serve a purpose, and which may be retained for local use should it ever become desirable to resort to the older divisions of Lower, Middle, and Upper.

The Lower Coal Measures may be divided into two divisions, and the Upper Coal Measures into five.

The Cherokee shales stand out so prominently that they will be left in a division to themselves, retaining their former name.

The upper division of the Lower Coal Measures may include everything above the Cherokee shales and below the top of the Pleasanton shales. That is, it may include the Oswego limestones, the Labette shales, the Pawnee limestone, both the Lower and Upper Pleasanton shales, and the Altamont limestone. As the Marmaton river crosses this formation almost at right angles, and has cut its channel into the upturned edges of them, revealing a good section of them from base to summit entirely within the state, the name Marmaton formation will be given, with stratigraphic limits as just outlined.[33]

In the Upper Coal Measures below the Lawrence shales found, counting from the base upwards, the Erie lim with their several shale partings; the Thayer shales; limestone; the Lane shales; and the Garnett limestor

33. It may be noted that the Marmaton formation as above given inclu Limestone Series" of Swallow, but more too, and the "Henrietta Limesto defined by Keyes—Proc. Ia. Acad. Sci., vol. iv., p. 23, 1897—Marbut did not as explained by Keyes it embraces the Pawnee limestone, the Labett limestone. Here the name Marmaton is given, not to replace these, mand for such a term, covering everything above the Cherokee shale stone.

division is well limited stratigraphically by the Pleasanton shales below and the Lawrence shales above, so that any one at all familiar with the stratigraphy of the country can easily locate the division lines. Here again we have a stream, the Pottawatomie river, almost entirely crossing this formation. The name Pottawatomie may, therefore, be given to the group of strata limited by the Pleasanton shales below and the Lawrence shales above.

The Lawrence shales are so distinct in character and, in connection with the Oread limestone overlying them, produce so prominent an escarpment, which extends entirely across the state from Leavenworth to the southern line, that they, with the overlying Oread limestone, may well be grouped in one general formation. It will be composed of the Lawrence shales [illegible] their included limestone and the Oread limestone, to which the name Douglas formation may be given, in allusion to the [illegible] toric county of Douglas located largely within their limits.

From the Oread limestone upward to the summit of the [illegible] shales we have another series of alternating beds of [illegible] and shales which in general characterization are decid[illegible] lar. This whole series may be grouped together in [illegible] tion, to which the name Shawnee may be given, [illegible] county containing the capital of our state.

Prosser having already given the names Wa[illegible] tonwood to two formations which include all the [illegible] above the Osage shales these names will be [illegible] plying to the uppermost general divisions of the [illegible] Measures.

The whole of the above outlined scheme [illegible] table printed on the next page.

TABLE II.—Divisions of the Kansas Coal Measures.

B. Upper Coal Measures.	7. Cottonwood Formation.	Cottonwood Shales. Cottonwood Limestone.
	6. Wabaunsee Formation.	A series of alternating limestones and shales to which individual names have not yet been given. Burlingame Limestone.
	5. Shawnee Formation.	Osage Shales. Topeka Limestones. Calhoun Shales. Deer Creek Limestone. Tecumseh Shales. Lecompton Limestones. Lecompton Shales.
	4. Douglas Formation.	Oread Limestones. Lawrence Shales.
	3. Pottawatomie Formation.	Garnett Limestones. Lane Shales. Iola Limestone. Thayer Shales. Erie Limestones.
A. Lower Coal Measures.	2. Marmaton Formation.	Upper Pleasanton Shales. Altamont Limestone. Lower Pleasanton Shales. Pawnee Limestone. Labette Shales. Oswego Limestones.
	1. Cherokee Shales.	Cherokee Shales.

NOMENCLATURE EMPLOYED.

Nomenclature, coupled with claims of priority, is the bane of the scientist. In the true sense of the term it is almost impossible for anyone to introduce new names without being liable to do an injustice to his predecessors. The history of science is filled with contentions for priority and struggles to avoid obscurity. The science of Geology is particularly unfortunate along these lines, perhaps more so than any other science. The earliest names applied to the great divisions, the Primary, Secondary, Tertiary, and Quaternary are almost gone. Likewise the term Azoic, everywhere employed in its day, had to yield to the inevitable and became obsolete on account of a discussion regarding the existence of a questionable fossil. In more recent times similar events have occurred, names suggested by geologists have been ignored by their contemporaries and successors, causing grief to friends and filling our literature with thousands of pages of acrimonious discussions.

It frequently happens that an investigator in a new field knowingly substitutes new names for old, sometimes with good reason, and sometimes apparently largely to have his name connected with future discussions of allied subjects. At other times, wholly unintentionally, names are ignored, sometimes because they are not in common use, or are meagerly published in out of the way documents difficult of access; sometimes on account of an inexcusable ignorance of the subject at hand on the part of the writer; but not infrequently on account of the unsystematic manner in which names have been applied and correlations made, compelling the new investigator to discontinue some of the terms and making it desirable, if not necessary, for him to introduce others.

The literature connected with the Trans-Mississippian geology has witnessed many instances in recent times falling under one or another of the above mentioned categories. Attempts have been made to change the nomenclature of the whole Carboniferous. The old and well established name Sub-Carboniferous

would be replaced by the new name Mississippian, and the well known name Coal Measures likewise by the new term Pennsylvanian. To a great extent the detailed nomenclature of the subdivisions of the Sub-Carboniferous, or Mississippian, has been remodeled with a retention of but a few of the older terms, and the introduction of new ones. Likewise the widely employed division of the Coal Measures designated by the well known terms Lower, Middle, and Upper have been relegated to obscurity and new geographic terms, the Des Moines and the Missourian, substituted in their stead. Not only this, but one writer has even ventured to suggest that the name of world-wide recognition, Permian, be laid aside and an American geographic term, the Oklahoman, be used in its place. In this way the whole of the Carboniferous, recognized alike in the Old world and the New, would have its great divisions known entirely by American geographic names suggested by American geologists to replace older names for the same subdivisions.

At this point in our nation's history it may seem a little less patriotic to adhere to the older terms and to refuse to accept the newer and strictly American geographic names. But if the former can be ignored, doing violence to all the rules of nomenclature known to science, or the latter accepted, merely on the suggestion of recent geologists, where can there be a stability to geologic nomenclature?

The Kansas Survey has accepted the term Mississippian and has used it throughout all of its publications thus far issued. But it must be confessed that the writer of this has grave apprehensions that the last decade has witnessed a disregard for the laws of nomenclature as generally adopted by investigators in other departments of science, and that American geology will suffer as a result. If the inter-continental members of the great geologic column are not sufficiently important to require the retention for them of long-established and well-known terms applicable the world over, then they should be given provincial or local names which do not imply any relation or position in the geologic column with the great divisions elsewhere in

America and in the world. Otherwise there are many reasons for holding that the modern departure, as a whole, is in general objectionable.

Coming now to more specific examples of Kansas geology, it may be stated that the nomenclature employed in this volume, and in preceding ones, in some respects is open to a portion of the criticisms above offered. On the other hand there are some conditions which, in a measure, render it necessary partially to ignore names formerly applied by other geologists. For more than forty years Kansas has been a favorite field for geological excursions. The old veterans, Meek and Hayden and Hawn and Newberry and Swallow and Broadhead and Mudge and St. John and Hay have traveled across the state in different directions, have written papers on this and that phase of Kansas geology, and brought the state into prominence as a rich field for paleontologists and stratigraphers who, in a broad way, are studying the general paleontology and stratigraphy of the great Mississippi valley. It is here that the Permian was first found in America, and it was from Kansas localities that those excellent yet general discussions of the Permian and underlying formations were made in early days by Meek and Hayden, and Swallow and Hawn. Geologic sections were made at Leavenworth, along the Kansas river, diagonally across the state to the Arkansas, and in various other directions here and there crossing the state in many places and covering, in one sense of the term, almost the whole of it.

Yet with all these preliminary excursions it was found that little had been done in the Coal Measures of the state to give a connected and systematic description of the individual horizons as they are now known to exist. In some of the sections the different terranes were merely numbered, no names whatever being applied. In other cases in which sections were run with an attempt to correlate strata with those known elsewhere, the names were applied from other parts of the state, but the correlations were imperfect and dissimilar strata were given the same geographic name. In some instances this was found to

be true even to the extent of discrepancies from 300 to 400 or 500 feet vertical distances, making it absolutely necessary that the whole of the correlations be gone over, some names discontinued, and others altered or changed.

With these conditions confronting us and becoming more apparent as work progressed it became desirable first of all to run a comparatively large number of sections from east to west, crossing the lines of outcropping of the Coal Measure formations to determine definitely what there was to be of service in subsequent correlations of the different strata. Accordingly during the season of 1893 sections were run along the Neosho and Verdigris rivers and along the A. T. & S. F. Railway from Cherryvale to Lawrence, and a preliminary report of the same published in the January number of the Kansas University Quarterly of 1894. In this report local names were given to the various limestone and shale formations encountered and such correlations were made as at that time seemed probable between the formations along the different sections.

The following season further work was done over substantially the same area. A section was run along the southern line of the state from Galena to Grenola; one in a north and south direction from Baxter Springs to the northern side of the state; the Neosho river section was reexamined; an east and west section was made from Fort Scott westward to near Yates Center; a section was run up the Osage river from the east line to Alma; the section along the Santa Fe from Cherryvale to Lawrence was reexamined; and an additional section was run westward from Atchison along the Missouri Pacific railway. In addition to these sections a great deal of work was done in actually tracing the line of outcroppings of the more important limestones, by following them mile by mile across the country. It was thought advisable to publish the results thus far gained, although it was recognized that some of the conclusions reached were only tentative. Accordingly a brief summary was published in the April number of the Kansas University Quarterly of 1895, and Volume I of the University Geological Surgey of Kansas appeared early in 1896, the copy being completed in 1895. In the

latter the details of these various sections were given both by word and by charts drawn to an exact scale. A reconnaissance geological map was likewise published and each of the supposed lines of outcroppings of the various limestones was represented.

During the summer of 1897 this stratigraphic work was entirely reviewed in the field, principally by Mr. Bennett, Doctor Adams, and the writer, each of whom had previously done a considerable portion of the work for Volume I. It was found that in a few cases previous correlations had been erroneous. This gave rise to the necessity of changing slightly the nomenclature previously employed.

Since the publication of the preliminary reports above referred to it has been learned that some of the names therein employed had been otherwise used. In 1893 Jenny[34] suggested the name Cherokee limestone for certain limestones in the Subcarboniferous in the southeast. Before his paper was published the name Cherokee shales was suggested by the writer and was used by different members of the Survey, but was first published by us in January, 1894. At that time Jenny's paper had not yet reached this office, probably due to no fault of Mr. Jenny. At the present time the name has appeared as widely in print referring to the shale bed as it has to the limestone. As the term "Cherokee" is only a part of the name, the remainder specifically describing the lithologic character of the horizon referred to, there may be no objection to its continuation. It is therefore retained.

The name Oswego limestones likewise first appeared in print in the Kansas University Quarterly in January, 1894, but had been used by the members of our Survey at least six months previous. The only objection known to the writer to such an use is in the possibility of doing an injustice to Professor Swallow who, in his report in 1866 referred to each member of the Oswego limestones by separate name. The lower of the two he named the Cement rock and the upper the Fort Scott limestone. It was not until the season of 1895 that the correlation of the

34. Jenny, W. P.: Lead and Zinc Deposits in the Mississippi Valley. Trans. Am. Inst. Mining Engineers, vol. xxii, p. 55, New York, 1893.

Oswego limestones in the Neosho river section and the Cement and Fort Scott limestones of Swallow was definitely established. There seems to be no objection to the use of the name Oswego limestones for the group, the two individual horizons being always separated by a definite and characteristic bed of shales. In our stratigraphic work it is found desirable to group the two under one name on account of their outcropping along the same line and being thus definitely associated. This usage need not prevent the use of the terms as Swallow employed them in 1866. Frequently his specific designation is desirable and may be continued.

The shale bed above the Oswego limestone seems not to have been named previously. At Doctor Adams's suggestion it will be called the Labette shales.

The limestone next succeeding was named the Pawnee limestone by Swallow[35] in 1866, which term is retained.

Above the Pawnee limestone are the heavy shale beds previously called the Pleasanton shales, a name which is now retained with slight modifications as explained later.

In the first instance of obvious erroneous correlations, as mentioned above, the Altamont limestone of Volume I was found to be the 8-foot limestone system described by Bennett in Chapter IV and represented in Plate IV as lying nearly a hundred feet beneath the Erie limestone. The error of correlating this with the lower member of the Erie limestone, which at Kansas City is known to correspond with Broadhead's Bethany Falls limestone No. 78, was thus discovered. The name Altamont may, therefore, be retained for this particular limestone, which seems to have no importance except in the southern part of the state. The presence of this limestone beneath the Erie makes it necessary to modify the name Pleasanton shales previously applied to the shale bed lying between the Pawnee and the Erie limestones. As the Altamont limestone is a wedge-shaped mass prominent in the south but disappearing northward, causing the Pleasanton shales to bifurcate southward, it is thought best to retain the name as previously

35. Swallow, G. C.: Geological Survey of Kansas, p. 24, Lawrence, 1866.

used for the northern part of the state, and to prefix the adjectives Lower and Upper in the southern, which thereby become local names.

Regarding the Erie limestones recently much has been written. Our Survey has demonstrated, we think, that the lower member of this series corresponds with the Bethany Falls limestone of Broadhead. It must be confessed, however, that there is room for doubting this proposition. In the bluffs at Kansas City, the southernmost point where Broadhead definitely located his Bethany Falls limestone, there are eight distinct limestone beds within 225 feet. The lowermost one, 20 feet thick, is the Bethany Falls rock of Broadhead. Southward these gradually decrease in number until west of Fort Scott, where Bennett described them in detail in Chapter IV of Volume I, there are but three principal limestones. Here the lowermost one of the three is 22 feet thick. Above this is a shale bed 7 feet thick, then 3 feet of limestone, then four feet of shale, and next a 16-foot mass of limestone. Above this heavy limestone there is a 9-foot shale bed, and then limestone 1½ feet thick, then 3 feet of shale, and lastly a heavy limestone 25 feet thick. These three limestones, the 22-foot one, the 16-foot one, and the 25-foot one, are the principal members which seem to extend southward to beyond the limits of the state. What has become of the other five members existing at Kansas City, and what these lesser intermediate limestones here amount to is not known, and can be determined only by the greatest amount of detailed work in tracing their outcroppings, a task which would have no special value and which would be so great that it probably never will be undertaken. Now the eight limestones at Kansas City outcrop practically along the same line southward and they en masse have been traced southward to the locality of the above section by Bennett, so that we know that they are continuous, but no one can say that this lower 22-foot bed of limestone is the Bethany Falls limestone of Broadhead, although it probably is.

On account of the uncertainties as above expressed and still further on account of the thickening of the shale partings which

reach 100 feet or more in Labette and Montgomery counties, convenience demands that local names be given to these heavy shale beds and to the thin limestones lying between them. For that reason the names Mound Valley shales, Mound Valley limestone, Cherryvale shales, and Independence limestone are here retained with the understanding that they are for local application and need not be brought into the discussion of the wider application of other names.

In 1895 objection was made to the use of the term Erie limestone[36] and a suggestion made that the term Bethany limestone be employed in its place. At the same time it was suggested that the Bethany Falls limestone of Broadhead, which constitutes the lowermost member of the Erie as they occur at Kansas City, is continuous northward with the lowermost limestone at Winterset, which was long ago called the Winterset limestone. Regarding the objections to the term Erie it may be said that they do not appear insurmountable, and are no greater apparently than might be raised to the use of many other terms. Keyes's introduction of the term Bethany as a group name dates nearly two years later than the introduction of the term Erie, and cannot replace it, according to the laws of priority, on that account. His use of the term is entirely different from that of Broadhead's term Bethany Falls limestone, the former being applied to a group of limestones and the latter to one specific limestone. The absence of a definite statement of the upper limit of the Bethany of Keyes adds to the difficulty of adopting it in Kansas. If it comprehends the Erie, the Iola, and the Garnett, there are serious objections to its use here for stratigraphic reasons. The term Erie is definitely applied to a definite limestone horizon, and, for the present at least, should be retained.

If the time ever comes when we can have traced these individual limestones consecutively from southern Kansas to central Iowa adjustments can readily be made so that the exact correlations over such great distances will be accompanied by a proper use of terms, governed by the laws of priority.

36. Keyes, Dr. C. R.: Am. Jour. Sci. [4], vol. 1, p. 243, New Haven, 1895.

Above the Erie limestones is the bed of shales, so heavy to the south, to which the name Thayer shales has been given, and which may be retained.

During the past season Doctor Adams found two or more lesser limestones lying near the summit of the Thayer shales which in local areas were relatively prominent. One of these he has dignified by a local term, the Earlton limestone. Likewise, to the shale bed between this and the overlying Iola limestone he has proposed the name Vilas shales. Each of these terms is looked upon as strictly local on account of the local character of the beds named.

Next in the ascending order, that prominent and persistent limestone horizon is reached which in 1894 was named the Iola limestone. At Kansas City this seems to constitute a part of the calcareous aggregate to which Keyes has applied the name Bethany limestones. Keyes's descriptions and limitations, however, are so general in character that no one can affirm or deny whether this be true or not. If it be true, then his term should not be applied in Kansas stratigraphy. For the Iola limestone is so widely separated from the Erie vertically and horizontally along its line of outcropping that it would be inconvenient and undesirable to extend the term so far. Throughout our whole state the Iola is much more intimately related with the overlying Garnett limestones than with the underlying Erie.

The Garnett limestones likewise appear in the bluffs at Argentine. Keyes has nowhere told us whether he would also include them under his term Bethany or not, and we are left to conjecture regarding this. Should he do the latter we will have still greater trouble, for they outcrop westward much farther away even than does the Iola.

The use of the term Lane shales to designate the shale bed between the Iola and Garnett limestones will be retained, as the name is applicable, and no objections seem to exist.

Regarding the limestones overlying the Lane shales some explanation should be given. When Kirk ran his section up the Neosho river in 1893 these limestones were temporarily called the Burlington limestones, but as it was then thought they were

the same as the limestones in the vicinity of Garnett and eastward the double name was given, Burlington or Garnett. Later the latter term only has been used in reference to them, as it was deemed advisable to use but one. A difficulty has arisen however, by an erroneous correlation. It was thought that a limestone existed, between the Iola and the Garnett, which was prominent in the vicinity of Carlyle, and which therefore was provisionally named the Carlyle limestone. This error was not discovered until the season of 1897, when Bennett found that the so-called Carlyle limestone and the Garnett limestones were the same. It is therefore incumbent to make a choice of names. As the two were suggested in the same paper priority does not apply. But as the term Garnett has been far more extensively used both in the charts and maps and in verbal descriptions it would seem desirable to retain it and to discontinue the term Carlyle.

A somewhat similar difficulty exists regarding the use of the term Lawrence shales. The name Leroy shales was applied in 1894 to this heavy shale bed in describing the Neosho river section, while in the same paper the term Lawrence shales was applied to the shales around Lawrence. At that time it was impossible to correlate the two, but now we know they are the same, and therefore one name must be dropped. Here, as before, it seems desirable to use the term which has appeared in print the most frequently, and has been the most extensively used in cartography. The term Leroy shales is therefore discontinued and the name Lawrence shales adopted.

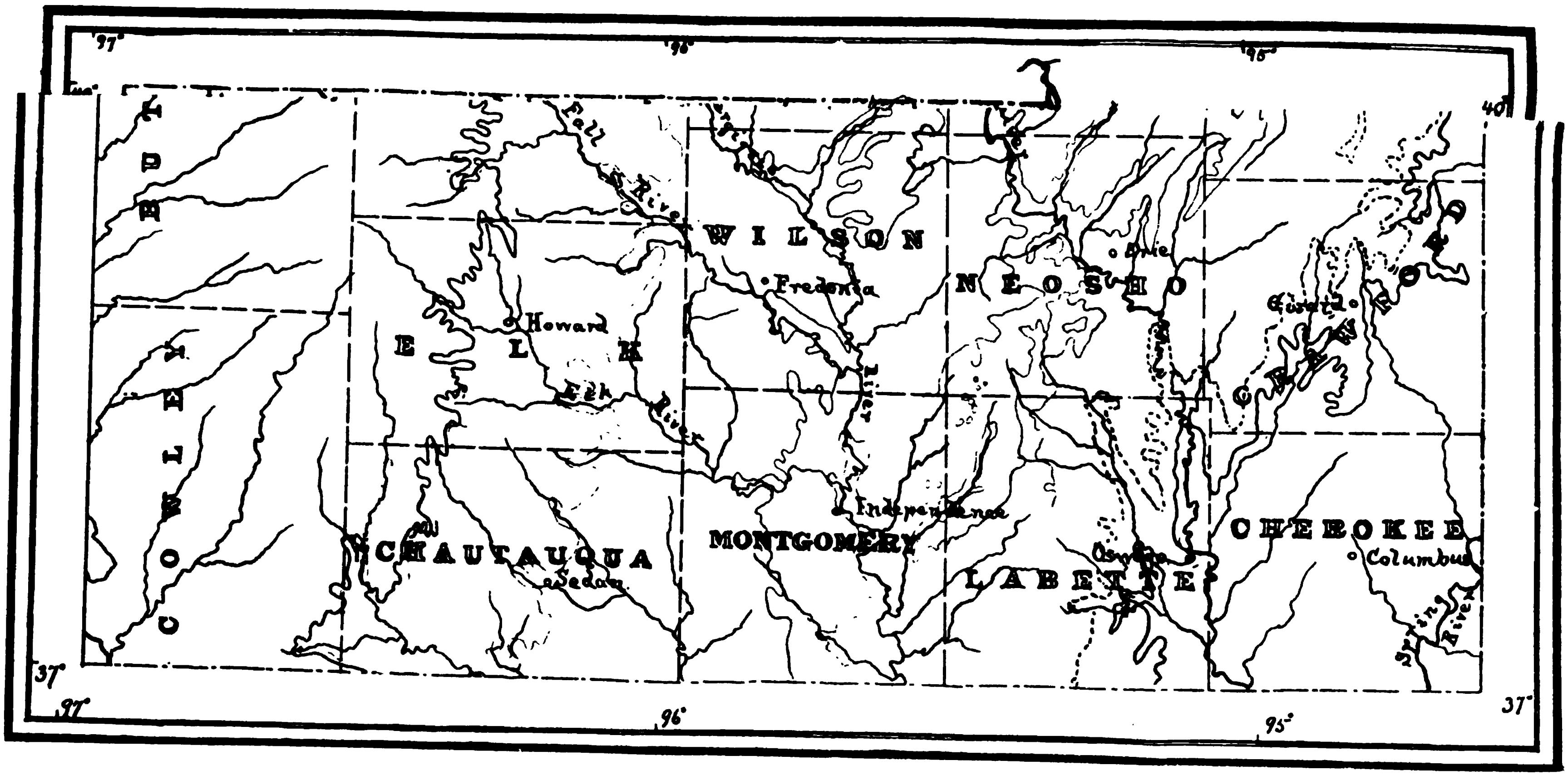
The name Oread given to the limestones covering the Lawrence shales, in 1894, seems to be the first applied and therefore will be retained.

The strata above the Oread limestones and below the Burlingame limestone previously have been named in part only. The correlations of the Kansas river section by Bennett with the one to the south by Adams have already been explained and need only be referred to here. With the Oread and Burlingame limestones traced entirely across the state, and with the three intervening limestones at every place studied there can be little

doubt that they are the same. It seems that Bennett's Lecompton and Deer Creek limestones have been brought closer together southward, and that they correspond to the two which Adams called the Elk Falls limestone. As Bennett's names were offered in 1896 they must be used whenever this correlation is accepted.

Adams's Howard limestone likewise seems to correspond with Bennett's Topeka limestone. The latter name having been in use since 1896 it should stand. Likewise Beede's names for the intervening shale beds, having been suggested in 1896, take precedence over the names suggested by Adams.

The name Osage shales as originally applied referred to the shales lying below a thin limestone overlying the Osage coal. Subsequent work has shown the unimportance of this limestone, so that it will not do to depend upon it as a division line marker. Neither will the Osage coal serve such a purpose, as it is by no means continuous. The coal is found occasionally here and there from the north side of the state to the south, but it is not continuous throughout more than half of this distance. From these considerations it seems desirable to let the name Osage apply to the entire shale bed above the Topeka limestone and below the Burlingame limestone. This is all the more desirable since Prosser has proposed that the overlying beds be grouped under the name Wabaunsee formation. Such a formation group should have a definite and natural line for its lower limitations. The Burlingame limestone also marks a prominent escarpment reaching all the way across the state, adding a strong physiographic reason for using it for the division line. This renders the name Burlingame shales superfluous and therefore it will be dropped.



MAP OF LIMESTONE OUTCROPPINGS.

LEGEND.

Burlingame Limestone.
Oread Limestones.
Garnett Limestones.
Iola Limestone.
Erie Limestones.
Pawnee Limestone.
Oswego Limestones.

PLATE VIII.

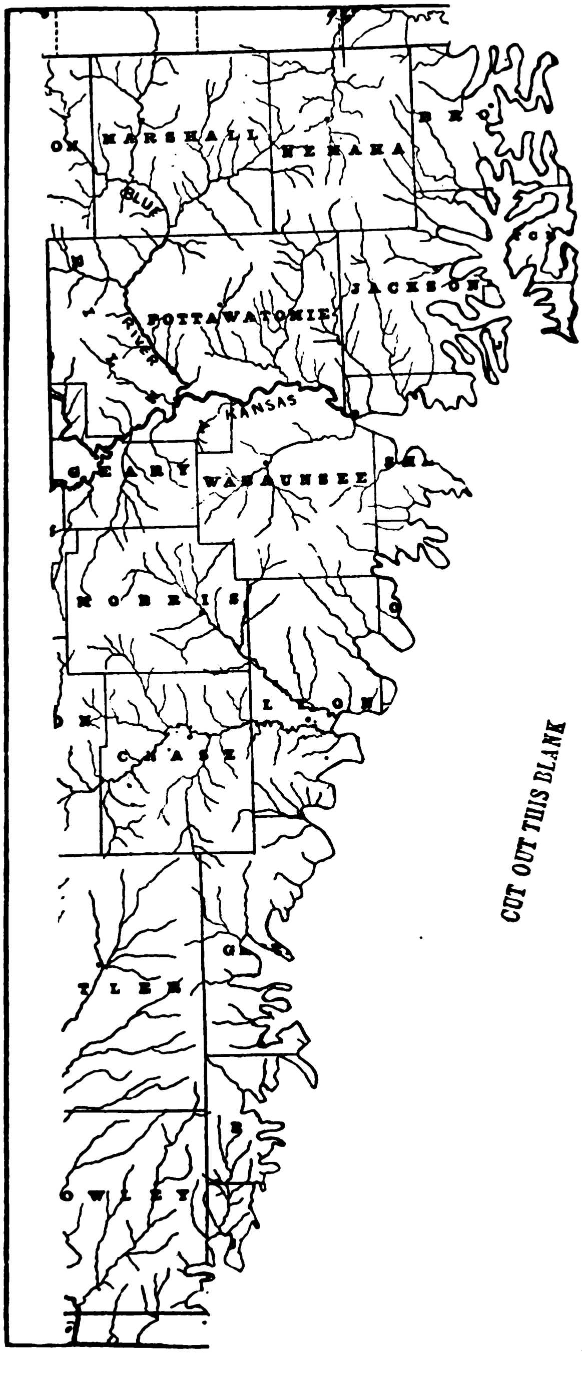
This Coal Map is designed to show how the coal bearing formations of Kansas pass under each other to the west. To understand the map properly the reader should cut out the portions in white from each of the first five leaves, so that the colored parts only remain. In that way the borders will fall in proper places so that each individual sheet will represent one formation passing under those above it. The decrease in intensity of shading represents the decreasing probability of finding coal in any one of these formations by prospecting for it to the west of the areas where it is exposed to the surface.

Plate IX accompanies Plate VIII and represents the coal bearing area in the Cretaceous rocks of north central Kansas. The heavy lines bound the surface exposures of the Dakota formation and the shaded areas within locate the Cretaceous coal.

LEGEND.

Burlingame Limestone.
Oread Limestones.
Iola and Garnett Limestones.
Erie Limestones.
Oswego and Pawnee Limestones.
Cherokee Shales.

University Geological Survey of Kansas.



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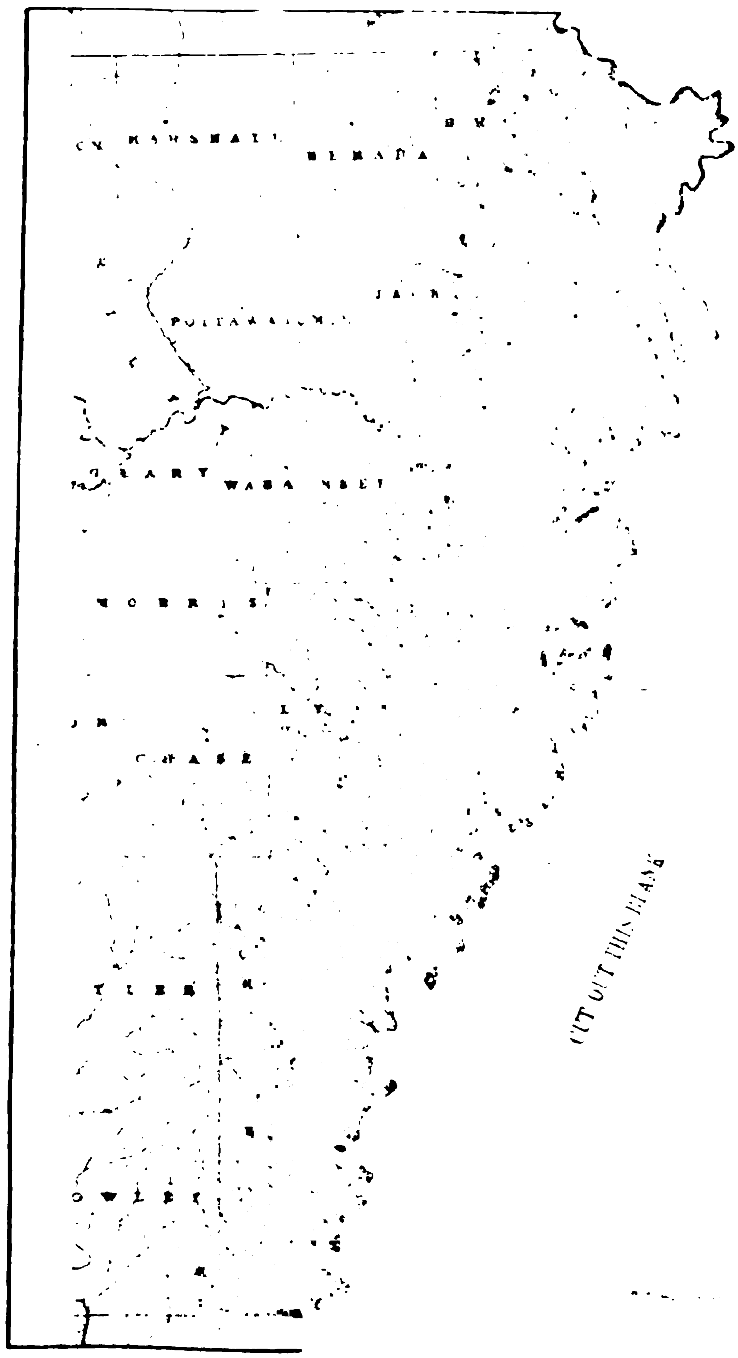

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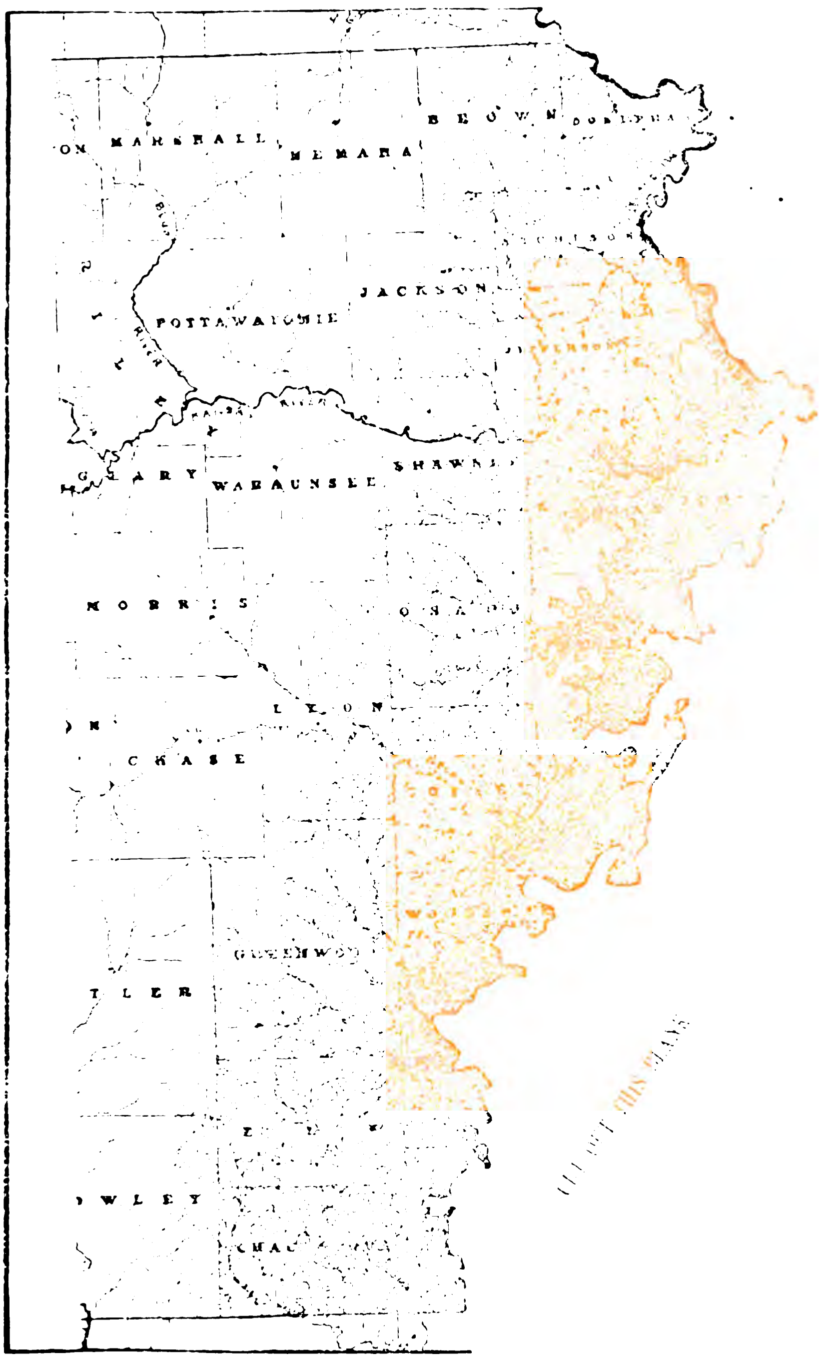
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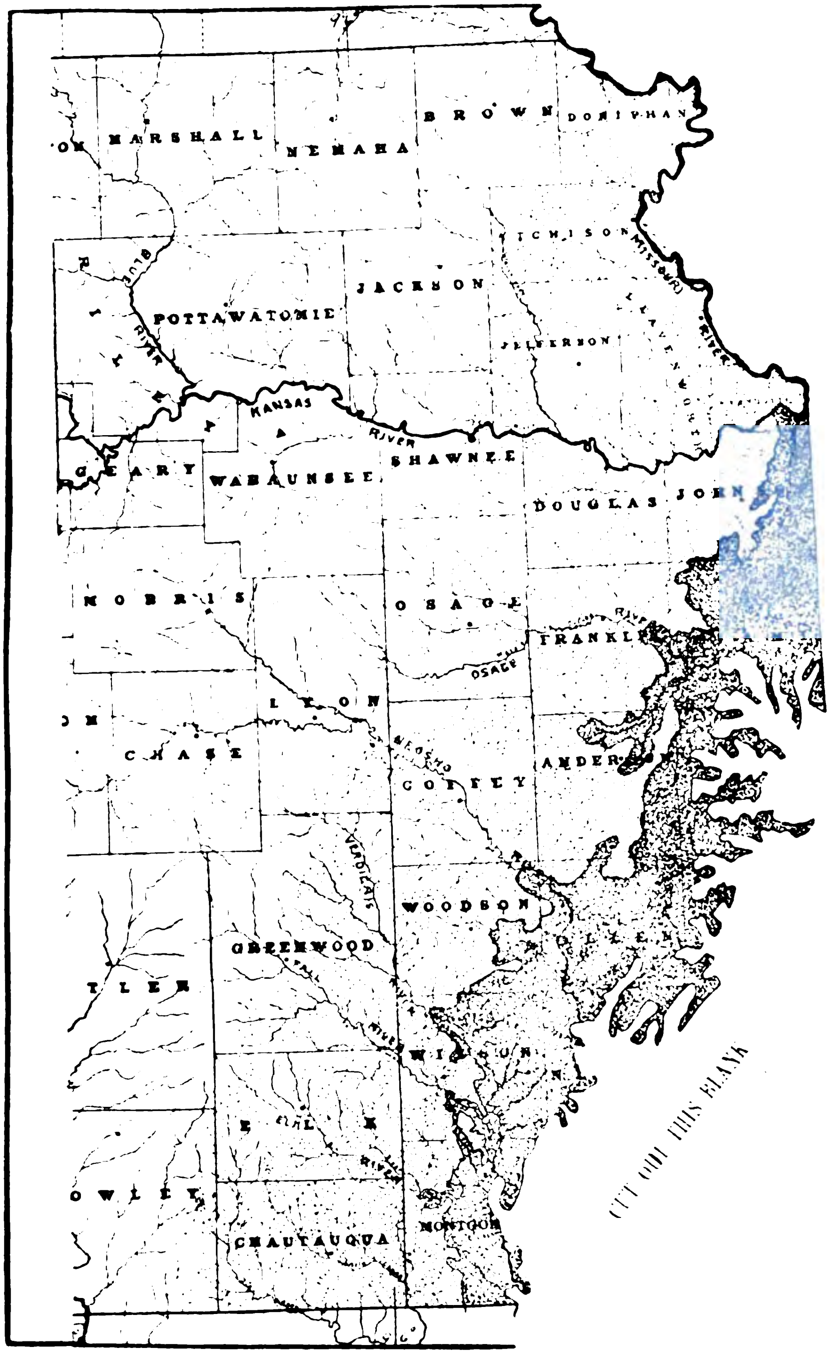

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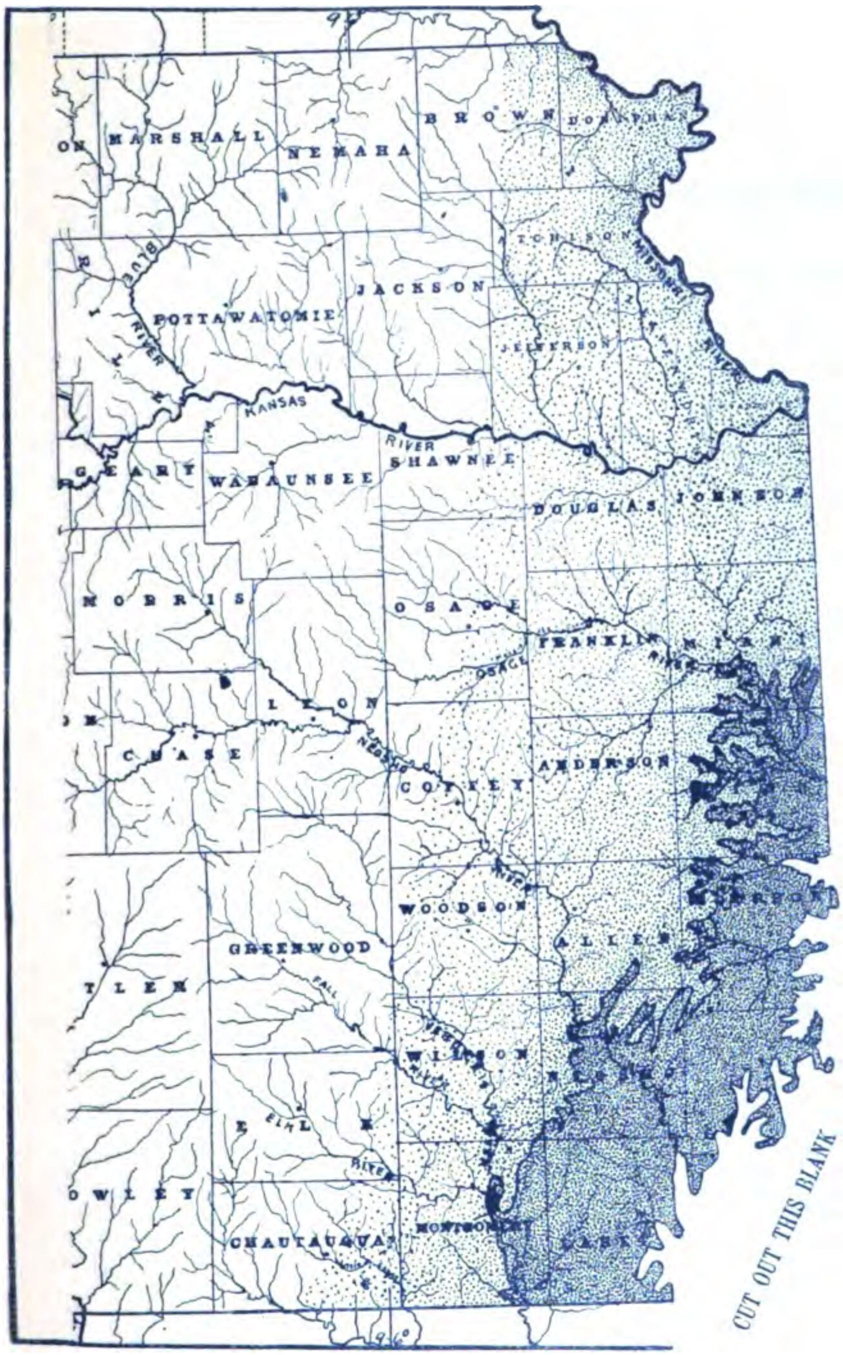

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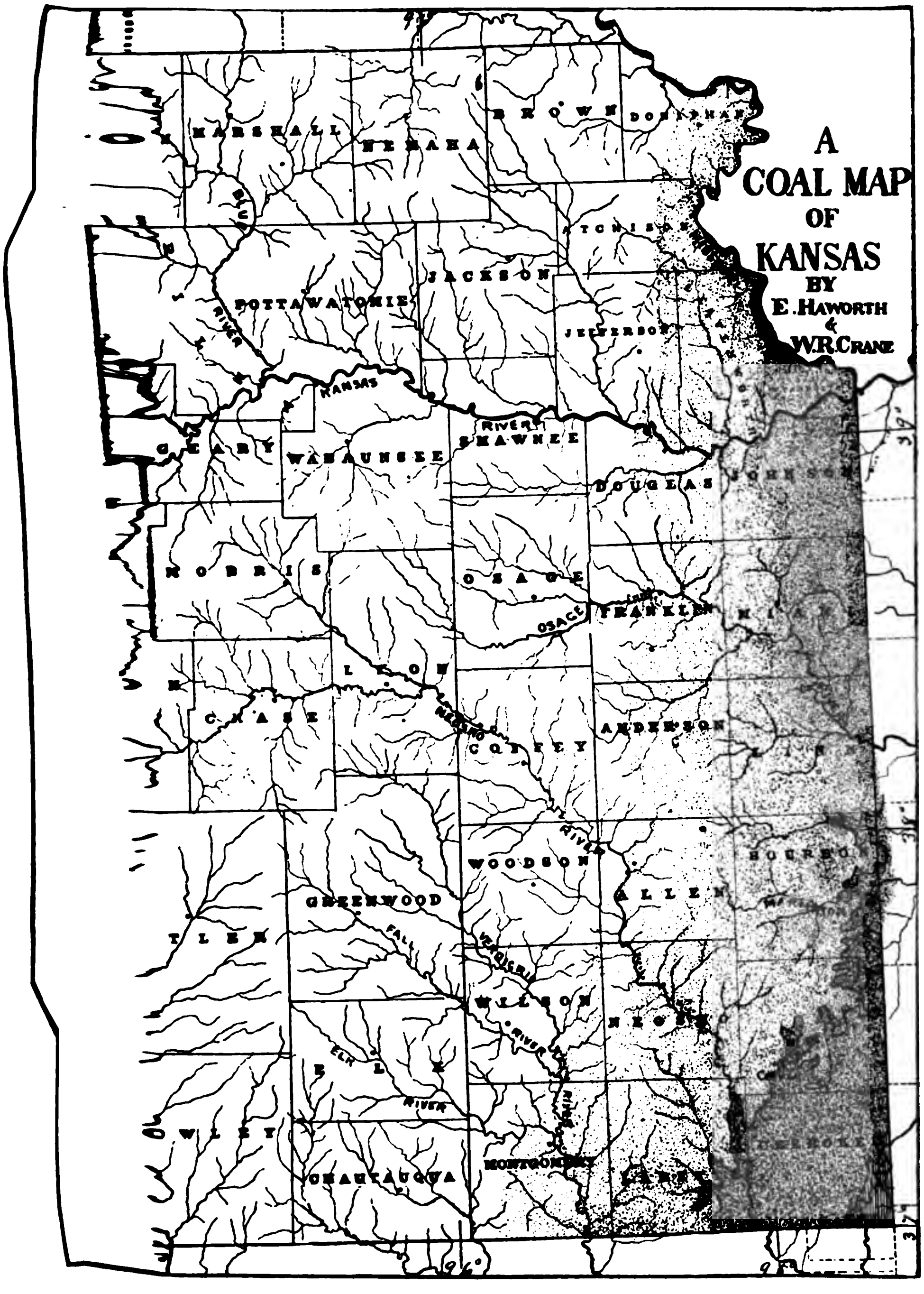
A
COAL MAP
OF
KANSAS
BY
E. HAWORTH
&
W.R. CRANE
MARSHALL
NEMAHA
BROWN
POTTAWATOMIE
JACKSON
JEFFERSON
KANSAS
RIVER
SHAWNEE
WABAUNSEE
GEARY
DOUGLAS
MORRIS
OSAGE
OSAGE
FRANKLIN
LYON
CHASE
COFFEY
ANDERSON
WOODSON
ALLEN
GREENWOOD
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WILSON
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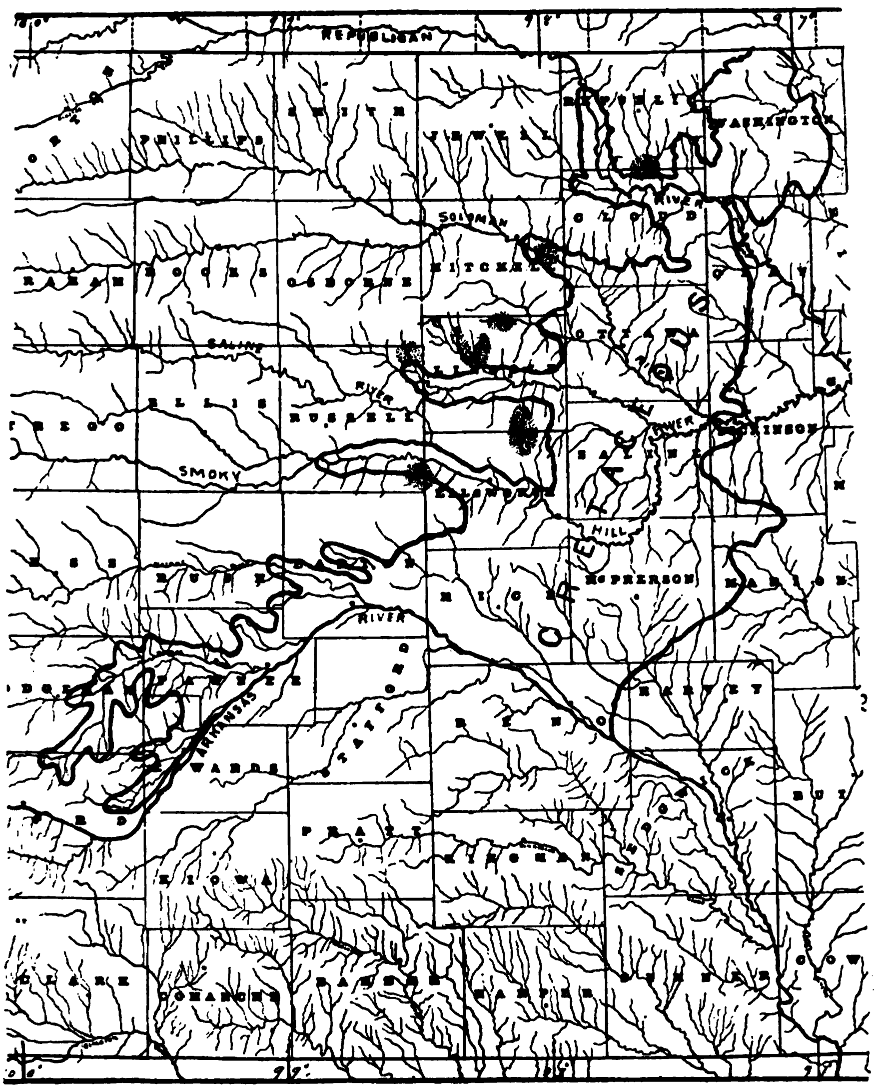
CHAUTAUQUA
MONTGOMERY



COAL MAP OF THE DAKOTA CRETACEOUS.

The heavy lines limit the Dakota areas, and the shaded parts show the locations of coal.

PART II.

GEOGRAPHY AND DETAILED STRATIGRAPHY OF THE KANSAS COAL MEASURES; DESCRIPTION OF MINES, MINING METHODS, AND MINING MACHINERY; CHEMICAL AND PHYSICAL PROPERTIES OF KANSAS COALS; OUTPUT AND COMMERCE; MINING DIRECTORY; AND MINING LAWS.

By W. R. CRANE.

CONTENTS FOR PART II.

ILLUSTRATIONS FOR PART II.

PLATES.

FIGURES IN TEXT.

GEOGRAPHY OF THE COAL MEASURES.

THE Coal Measures of Kansas are situated in the eastern part of the state and cover about one-fourth of the entire area, or about 20,000 square miles. The western part of this, however, seems to be entirely barren of coal and therefore need not be considered in this connection. The coal deposits furthest to the west of any thus far discovered in the Coal Measures form an irregular line crossing the state from eastern Brown county to western Chautauqua county leaving about 15,000 square miles to the east that may be looked upon as a productive area. In addition to the Coal Measure area we have the Cretaceous coal area in the north central part of the state which furnishes a considerable quantity of coal for the local trade and which in the future may become much more productive than at present.

Of the 15,000 square miles of productive coal fields in eastern Kansas only a small proportion is actually productive at the present time. The mines that are worked the most extensively are located far in the southeast part of the state in Cherokee and Crawford counties, covering an area trending northeast and southwest in the vicinity of Mineral, Weir City, Fleming, Chicopee, Pittsburg, Frontenac, and other points as far to the northeast as Arcadia. Here is produced more than two-thirds of all the coal mined in the state as mining is conducted at present. A little to the northwest of this area are located the mines of Fort Scott, Pleasanton, and Mound City, and still farther west those in the vicinity of Thayer.

Beyond these limits there is another belt of country with productive mines likewise trending northeast and southwest, reaching from near Burlington by way of Ransomville, Pomona, and Lawrence to Leavenworth and Atchison. Throughout the whole of this territory coal has been mined at different times

and of varying amounts. At present the mines are actively worked at Ransomville and in the vicinity of Pomona in Franklin county, and at Leavenworth and Atchison.

Still farther to the northwest is another zone of productive coal mines, the output from which is of great commercial importance. This zone reaches from Chautauqua county on the southern borders northeast by way of Eureka, Lebo, Osage City, Burlingame, and Topeka, across into Jefferson, Atchison, Doniphan, and Brown counties, with a varied mining activity at different places throughout the whole extent. Mining is the most active in Osage county in the vicinity of Burlingame and Osage City, but at scores of other places throughout the extent named local mines are operated for the local trade, particularly through the winter season.

Within the area above mentioned not less than twenty-three counties are coal producers. They are as follows:

Atchison.	Crawford.	Jefferson.	Neosho.
Bourbon.	Douglas.	Labette.	Osage.
Brown.	Elk.	Leavenworth.	Shawnee.
Chautauqua.	Franklin.	Linn.	Wabaunsee.
Cherokee.	Greenwood.	Lyon.	Wilson.
Coffey.	Jackson.	Montgomery.	

The Cretaceous area in the central part of the state has produced coal in the following six counties:

Cloud.	Lincoln.	Republic.
Ellsworth.	Mitchell.	Russell.

Within the counties above named coal mining at present is conducted in the following places:

Atchison County.—The coal mines of Atchison county are principally upon the banks of the Missouri river, the most important mines thus far being operated in the vicinity of Atchison. Here Donald Brothers operate a drift mine two miles south of Atchison, the mine being connected with the Union Pacific railway. Also the Challis mine is well operated, being located two miles south of Atchison and likewise connected with the

Union Pacific railway. Coal is mined near Huron, in the northern part of the county, and also along Stranger creek, in the northeastern part. The coal at Atchison comes from a lower level and different geologic horizon from that in other parts of the county.

Bourbon County.—In the early days of coal mining in Kansas Bourbon county ranked among the first, but at present its rank is of less importance. Coal is mined principally by the strip pit process in almost every direction from Fort Scott and at many other points in the eastern half of the county. It generally occurs near the surface and outcrops along the bluffs of the ravines so that the lines of strip pits follow the irregular outlines of the bluffs. At present the mining is principally limited to local trade.

Brown County.—Brown county furnishes but little coal and that to supply the local demand. At the present mines are operated principally during the winter season in the northern part of the county along Roy's creek, and at a few points both north and south of Robinson along Wolf creek, and at some of the points to the southeast of Everest.

Chautauqua County.—Chautauqua county has furnished in the aggregate a considerable per cent. of the coal that has been used for local consumption. The coal beds here are from 12 to 16 inches thick and consequently do not justify extensive mining. In the vicinity of Leeds mines have been operated for years during the winter season and occasionally during a part of the summer. Both to the northeast and the southwest of Leeds mining has been carried on to a limited extent but nowhere within the county has coal been produced for the general market.

Cherokee County.—Cherokee county was the leading coal producing county of the state for a number of years and has yielded the position of first rank to Crawford county only during the last decade. This county was open for settlement in 1866 and before twelve months had passed coal was located at a number of places in the southeastern part of the county, particularly

along the highlands south of Shawnee creek to the east and southeast of Columbus. The coal beds in this immediate vicinity are thin and the coal of a somewhat inferior grade. When the heavier beds were found farther to the northwest in the county the coal mining operations soon became so extensive and the competition so sharp that the earlier mines were practically abandoned and have since been worked almost exclusively for local consumption and during periods of scarcity of coal due to coal miners' strikes or other causes. The heavier coal beds were first extensively operated at Weir City, but since mines were opened in many places along the northeastern and southwestern line passing through Weir City and Scammon and reaching to the northeast into Crawford county. At present this whole northeastern part of Cherokee county is one coal mining area, it being difficult to find a position from which no coal mining shaft can be seen.

The principal mines are clustered about Mineral, Stippville, Turk, Scammon, Mackie, and Weir, although some of the mines reach farther to the west and northwest. In the southern and southwestern part of the county coal is not very abundant but at different places small deposits are known which would prove remunerative were the price of coal twenty-five per cent. higher than it has been during the last decade. The following detailed account is given locating the principal mines within the county, beginning on the south and passing northward:

1. The George Robinson mine is located two and one-half miles north of Columbus; has no railway connections.

2. The Columbus Coal Company has a shaft located at Stippville, on the Kansas City, Fort Scott & Memphis railway.

3. The Scammon Coal Company's shaft, located about three and one-half miles north of Columbus, is connected by switch with the Kansas City, Fort Scott & Memphis railway.

4. Peter Graham's shaft is located in the neighborhood of one and one-half miles southwest of Scammon. Coal is hauled by wagon to a switch on the Kansas City, Fort Scott & Memphis railway.

5. The Southwestern Coal and Improvement Company's

shaft No. 6 is located four miles west of Scammon and is connected with the Missouri, Kansas & Texas railway by switch.

6. The Durkee Coal Company's shaft No. 3 is located about one mile north and west of Scammon and is connected by switch with the Kansas City, Fort Scott & Memphis railway.

7. The Central Coal and Coke Company's mine No. 7 is located one mile north of Scammon and is connected with the Kansas City, Fort Scott & Memphis railway.

8. The Excelsior Coal Mining Company's mine is located south of Weir City. It has no railroad connections.

9. The James Hall shaft is located two miles south and west of Weir City and has no railroad connections.

10. The Bennett Slope Shaft is located in the southeastern city limits of Weir City and has no railroad connections.

11. The Central Coal and Coke Company's shaft No. 6 is located one mile south of Weir City and is connected by switch with the Kansas City, Fort Scott & Memphis railway.

12. The J. Durkee Coal Mining Company's shaft No. 1 is located in Weir City and is connected with the Kansas City, Fort Scott & Memphis railway.

13. The Hamilton and Braidwood Coal Company's mine No. 1 is located one mile north and west of Weir City and is connected with the Kansas City, Fort Scott & Memphis railway.

14. The Hamilton and Braidwood Coal Company's mine No. 2 is located three-quarters of a mile west of their No. 1 and is connected with the Kansas City, Fort Scott & Memphis railway.

15. The Kansas and Texas Coal Company's shaft No. 7 is located two miles north of Weir City and is connected with the Pittsburg and Weir City branch of the St. Louis & San Francisco railway.

16. The Kansas and Texas Coal Company's shaft No. 18 is about two and one-half miles north of Weir City and is connected with the St. Louis & San Francisco and the Kansas City, Fort Scott & Memphis railways.

17. The W. H. Barrett mine No. 1, known as the "Daisy" shaft, is located a trifle north and west of Weir City.

18. The Central Coal and Coke Company's shaft No. 8 is

located two miles southwest of Weir City and is connected by switch with the Kansas City, Fort Scott & Memphis railway.

19. The Weir Brothers mine No. 2 is located one and one-half miles west of Weir City and is connected by switch with the Pittsburg and Weir branch of the St. Louis & San Francisco railway.

20. The Central Coal and Coke Company's shaft No. 5 is located one and one-half miles west of Weir City and is connected by switch with the Kansas City, Fort Scott & Memphis railway.

21. The Western Prospecting Company's shaft is located north of Mineral City four or five miles.

22. The Southwestern Coal and Improvement Company's mine No. 8 is located at Mineral City and is connected with the Missouri, Kansas & Texas railway.

23. The J. H. Durkee Coal Company's shaft No. 5 is located northeast of Weir and is connected with the St. Louis & San Francisco railway.

24. The Kansas and Texas Coal Company's mine No. 23 is located northeast of Weir and is connected with the St. Louis & San Francisco railway.

25. The Southwestern Coal and Improvement Company's mine No. 7 is located at Mineral City and is connected with the Missouri, Kansas & Texas railway.

26. The Stone and Dixon Coal Company's mine No. 1 is located at Scammon and is connected with smelter switch of the Kansas City, Fort Scott & Memphis railway.

27. The J. C. Graham Coal Company's mine No. 1 is located northwest of Scammon and is connected with the Kansas City, Fort Scott & Memphis railway.

28. The J. R. Crowe Coal Company's mine is located three and a half miles north of Columbus and is connected with the Kansas City, Fort Scott & Memphis railway.

In addition to these, coal is mined in many places by the strip pit process, not only in the northwestern part of the county but to a much greater extent in the immediate vicinity of the larger mines about Weir City and Scammon. A large proportion of

the coal used by the zinc smelters is obtained in this way. As the coal beds dip to the northwest they outcrop at the surface to the southeast, forming the irregular northeast and southwest line already referred to. The mines most extensively operated at present reach the coal by shafting, but large quantities of the coal lying near the surface is still untouched and will remain so for years although mining by stripping is conducted to so great an extent.

Coffey County.—The coal in this county is obtained principally from the northwest part in the vicinity of Lebo, although small quantities have been taken out in the northeastern part of the county. At Lebo the coal is from 14 to 16 inches in thickness and furnishes a good supply for the local trade and that of the surrounding country. It is taken by wagon north, south, and west for considerable distances, even twenty or thirty miles. It is mined principally by the stripping process, although at different places, particularly about Lebo, the tunneling process is resorted to, starting from an outcropping along the banks of a stream. The coal here is of the same grade as that of Osage county.

Crawford County.—Crawford county is the largest coal producer in the state. For the past five years it has averaged more than two-fifths of the total state production. The coal here is in every respect practically the same as that of Cherokee county, and the history of the development of mining is about the same. Pittsburg is located in the center of the coal producing district with mines in operation in the vicinity of all the adjoining towns such as Cherokee, Fleming, Chicopee, Litchfield, Frontenac, Nelson, Fuller, Mulberry, and Arcadia. The following is a detailed location of the mines operated in this county:

1. The Western Coal and Mining Company's shaft No. 2 is located at Fleming and is connected with the Missouri Pacific railway.
2. The Western Coal and Mining Company's shaft No. 3 is lo-

cated one mile north and east of Fleming and is connected with the Missouri Pacific railway.

3. The Durkee Coal Mining Company's shaft No. 4 is located two and a half miles northeast of Weir City and is connected with the Cherryvale division of the Kansas City, Fort Scott & Memphis railway.

4. The T. M. Bennett mine is located five miles southwest of Pittsburg and is connected with the Santa Fe railway.

5. The John Davis Coal Company's mine is located at Cherokee, on the Kansas City, Fort Scott & Memphis railway.

6. The Lake and Gilmore shaft is located one and one-half miles south and east of Pittsburg and is not connected with the railroad.

7. M. A. Redding's slope shaft is located one mile south of Playter's lake, Pittsburg. It has no railroad connections.

8. J. N. Cessna's slope shaft is located one mile south of Playter's lake, Pittsburg, and has no railroad connections.

9. O. L. Hovey's slope shaft is located one mile south of Playter's lake, Pittsburg, and has no railroad connections.

10. The Esten and Oakes slope shaft is located one mile south of Playter's lake, Pittsburg, and has no railroad connections.

11. The C. A. Beck strippings are located one mile south of Pittsburg proper and are connected with the Missouri Pacific railway.

12. The Cherokee and Pittsburg Coal Mining Company's shaft No. 4 is located at Chicopee and is connected by switch with the Santa Fe railway.

13. The Cherokee and Pittsburg Coal Mining Company's shaft No. 5 is located two miles south and west of Pittsburg and is connected with the Santa Fe railway.

14. The Wear Coal Company's mine No. 5 is located two miles northeast of Pittsburg and is connected by switch with the Cherryvale division of the Kansas City, Fort Scott & Memphis railway.

15. The Wear Coal Company's mine No. 6 is located at Pittsburg. Coal is hauled by wagons to railroad switch.

16. The Wear Coal Company's shaft No. 2 is located four

miles west of Pittsburg at Kirkwood, on the Cherryvale division of the Kansas City, Fort Scott & Memphis railway.

17. The Kansas and Texas Coal Company's shaft No. 20 is located one mile west of Pittsburg and is connected with the Pittsburg and Weir City branch of the St. Louis & San Francisco railway.

18. The W. A. Swan & Co.'s mine is located north and east of Pittsburg. It has no railroad connections.

19. The Sheldon Coal and Mining Company's shaft No. 1 is located two miles north of Pittsburg. Coal is hauled by wagon to a Santa Fe switch.

20. The Dewey and Walker shaft is located two miles northeast of Pittsburg. It has no railroad connections.

21. J. H. Jenness' mine is located about one mile south and west of the Missouri Pacific depot at Pittsburg. It has no railroad connections.

22. The R. Wilson shaft is located on the line of the Pittsburg & Frontenac electric railway. It has no other railroad connections.

23. The Wright Brothers' strippings are located two miles southeast of Pittsburg. They have no railroad connections.

24. The Hamilton and Grant mine is located three miles north of Weir City and is connected with the Cherryvale division of the Kansas City, Fort Scott & Memphis railway.

25. The Pittsburg Coal and Coke Company's mine No. 2 is located five miles southwest of Pittsburg, on the Kansas City, Fort Scott & Memphis railway.

26. The Arnott and Lanyon shaft is located two miles northeast of Pittsburg and is connected with the Santa Fe and Kansas City, Pittsburg & Gulf railways.

27. The Cherokee and Pittsburg Coal Mining Company's mine No. 1 is located at Frontenac and is connected with the Santa Fe railway.

28. The Cherokee and Pittsburg Coal Mining Company's mine No. 2 is located at Frontenac and is connected with the Santa Fe railway.

29. The Kansas and Texas Coal Company's mine No. 37 is

located four miles northeast of Pittsburg and is connected with the St. Louis & San Francisco, Missouri Pacific, and Kansas City, Fort Scott & Memphis railways.

30. The Pittsburg and Midway Coal Company's mine No. 4 is located at Midway and is connected with the Santa Fe, St. Louis & San Francisco, and Kansas City, Fort Scott & Memphis railways.

31. The Pittsburg and Midway Coal Company's mine No. 5 is located at Midway and is connected with the Santa Fe railway.

32. The J. H. Durkee Coal Company's shaft is located three-fourths of a mile south of Midway and has no railroad connections.

33. The Carleton stripping is located about three-fourths of a mile north and east of Frontenac.

34. The Western Coal Mining Company's mine No. 4 is located at Yale and is connected with the Fort Scott and Yale branch of the Missouri Pacific railway.

35. The Western Coal Mining Company's mine No. 5 is located at Yale, on the Missouri Pacific railway.

36. The Central Coal and Coke Company's shaft No. 9 is located at Nelson and is connected with the Pittsburg & Gulf railway.

37. The Southwestern Coal Company's mine is located at Cornell and is connected with the Missouri Pacific railway.

38. The Braidwood and McLusky Coal Company's mine is located at Coalvale and is connected with the Kansas City, Fort Scott & Memphis railway.

39. The Arthur Bell drift shaft is located one-half mile east of Coalvale and is connected with the Kansas City, Fort Scott & Memphis railway.

40. The Jack Russell Coal Company's mine is located at Coalvale, on the Kansas City, Fort Scott & Memphis railway.

41. The Fuller Coal Company's shaft No. 1 is located two and a half miles south of Mulberry, on the Pittsburg & Gulf railway.

42. The Mount Carmel Coal Company's mine No. 1 is located at Frontenac and is connected with the Santa Fe railway.

43. The Mount Carmel Coal Company's mine No. 5 is located at Chicopee and is connected with the Santa Fe railway.

44. The Midland Coal and Smelting Company's mine is located three one-half miles west of Cherokee and is connected with the Kansas City, Fort Scott & Memphis railway.

45. The Western Coal and Mining Company's mine No. 7 is located southeast of Fleming and is connected with the Missouri Pacific railway.

46. William H. Barrett's mine No. 3 is located northeast of Weir and is connected with the St. Louis & San Francisco railway.

47. The Weir Junction Coal Company's mine is located north of Weir City and is connected with the Kansas City, Fort Scott & Memphis railway.

48. The Empire Coal and Mining Company's mines Nos. 1 and 2 are located at Coalvale and connected with the Kansas City, Fort Scott & Memphis railway.

49. The J. E. Lewis mine is located one mile southwest of Coalvale and has no railroad connections.

50. Miller Brothers and Company's mine is located north of Mulberry and is on the Kansas City, Fort Scott & Memphis railway.

51. The Kansas Commercial Company's mine No. 1 is located at Fuller and is connected with the Pittsburg & Gulf railway.

52. The Eureka Coal and Mining Company's mine No. 1 is located one and three-fourths miles north and one mile west of Frontenac.

53. Wilson Brothers' mine is located a half mile north of Pittsburg, on the street-car line to Frontenac.

Stripping has been carried on in a great many places in Crawford county. Old strip pits may be found all around Pittsburg, especially to the north and east. From the south line of Crawford county northward along the state line to the north county line of Linn county more or less coal has been, and is being, removed by stripping. There is almost a continuous line of old strip pits north of Pittsburg for ten to fifteen miles, while

south and west of Pittsburg to the distance of three or four miles, especially along the creeks, the territory has been stripped extensively for coal. In the brick works at Pittsburg the coal consumed is taken principally directly from the clay-pits.

Douglas County — Douglas county at present is furnishing no coal although coal can be found under more than half of it. The Douglas coal is in thin beds and therefore cannot be mined to advantage so long as the market price of coal is as low as it is at present. In earlier times coal was mined over a large area to the south, southeast, and southwest of Lawrence, generally by the stripping process but not infrequently by shafting. During the recent period of low prices these numerous country shafts and strip pits have been closed because the farmer can buy his coal on the streets of Lawrence cheaper than he can hire it mined. Yet during the winter of 1897–'98 some coal was mined on Deer creek in the northwest part of the county and placed on the Lawrence market.

Elk County.—Elk county produces but little coal and that which is produced is not equal in quality to the coal from the southeastern part of the state. The mining in this county is similar to that in Chautauqua county to the south, only that Elk produces a smaller amount than does Chautauqua. The principal mines are located some miles to the east of Grenola and are operated entirely for local consumption.

Franklin County.—Franklin county produces coal for local consumption, for use by the railroads passing through the county, and supplies a large proportion of the coal consumed in Ottawa and other points within the county. The mines are found in the western half of the county, particularly in the vicinity of Pomona and Ransomville, but there are numerous other mines operated by stripping even throughout the greater part of the southwestern fourth of the county, particularly to the east of Williamsburg and Silkville. The coal is fair in quality and can be mined at a profit for the trade above mentioned.

Greenwood County.—Greenwood county produces but little

coal and that which she does produce is similar in quantity and quality to the coal obtained from Chautauqua and Elk counties. There is a line of strip pits on the eastern side of the Santa Fe railway extending both to the northeast and southwest of Eureka, reaching Elk county on the south and Lyon county and Coffey county on the north.

Jackson County.— This county produces almost no coal at all, the only mines known being in the extreme southeastern part of the county along Muddy creek and Cedar creek. As far as developed it is of little importance.

Jefferson County.— Jefferson county produces more coal than Jackson but still not enough at the present to be of any considerable commercial importance. Thin beds of coal are found in many places along the ravines in the southern part of the county, north of the Kansas river valley, and also in the territory tributary to the Delaware river in the northwestern part. Coal mining has been conducted to a limited extent for a number of years by the strip pit process and by tunneling into the hillsides. The output of the mines constitutes but a small per cent. of the total coal consumption of the county.

Labette County.— Labette county in the aggregate produces a considerable amount of coal although not enough to entirely supply the local demand. Mining has been confined principally to the banks of the Neosho river and its tributaries in the eastern part of the county, particularly in the vicinity of Oswego.

Leavenworth County.— Leavenworth county is one of the four leading producers of the state, being about equal in production to Osage county. The coal of Leavenworth county is obtained from great depths by shafting. The mines are located in the vicinity of Leavenworth city and to the south at Lansing. Although it is by no means demonstrated that coal of equal value could not be obtained elsewhere in the county. At present the following are the more important mines:

1. The Leavenworth Coal Company's mine is located on the west bank of the Missouri river, just out of the city limits to

the north, and is connected with the Union Pacific and Missouri Pacific railways.

2. The Home-Riverside Coal Company's mine No. 1 is located on the west bank of the Missouri river in the southeastern part of the city and is connected with the Union Pacific, Missouri Pacific, and Santa Fe railways.

3. The Home-Riverside mine No. 2 is located on the west bank of the Missouri river one mile south from No. 1 and is connected with the Union Pacific, Missouri Pacific, and Santa Fe railways.

4. The penitentiary mine is located at Lansing and is connected with the Santa Fe, the Missouri Pacific, the Union Pacific, and the Kansas City & Northwestern railways.

A large amount of coal is placed upon the market from these mines, although they are placed at a disadvantage with respect to the other mines of the state, by the great depth to which the mining operations are confined, the cost of sinking the shafts, and the various natural obstacles met with, such as water, poor floor, etc.

Linn County.—In quantity and quality of coal Linn county should rank high, although her proximity to Cherokee and Crawford counties has greatly hindered her development. Linn county has at least two beds of coal either of which could be profitably worked were the price one or two cents more per bushel than it now is. However, she is fifth in coal production. Coal is mined in many places in eastern Linn county, particularly the southeastern fourth of the county. The coal is obtained both by the strip pit process and by shafting, dependent upon the depth below the surface at which the coal is found.

Prescott is one of the most important mining points in the southern part of the county. Little or no coal is mined within a half mile of Prescott, but from a distance of one and a half to three miles east, south, and west coal mining, principally by stripping, has been carried on very extensively. The coal stratum operated on in the Bourbon county mines is probably the one worked in the vicinity of Prescott. It is found just above the

Pawnee limestone and is mined from within a half mile west of Prescott westward for four or five miles. It is stripped along the creeks and three miles west of Prescott is shafted for. The coal at this point is 28 inches thick. Not much coal is removed here during the summer months but a considerable amount is mined during the winter. The following are the more important localities where coal is removed by shafts and strip pits in the vicinity of Prescott:

1. Tarn's strippings are located one mile west of Prescott on the north bank of Laberdy creek.

2. The Caffett and McIntyre mine is located three miles south and west of Prescott.

3. Mrs. Tanny's strippings are located one mile west of Prescott.

4. James Borey's strippings are located two miles east of Prescott and one-half mile north.

5. Joe Billing's strippings are located two miles east of Prescott on Indian creek.

6. John Hurl's strippings are located three miles east of Prescott on Indian creek.

7. Link Nine's strippings are located three miles east and one-half mile north of Prescott on Indian creek.

8. John Lewis's mine is located one and three-fourths miles east and one-half mile south of Prescott.

9. Three miles west and one mile south of Prescott is the only shaft located in this vicinity; the names of the operators are unknown.

West and south of the last mentioned shaft considerable coal is stripped. In this locality a 40-inch coal stratum was reported as having been found, but this claim could not be substantiated.

The next point of importance on the north is Pleasanton. The coal mines here are located principally to the north and east of the town. The exact locations of a few of the more recently worked mines are as follows:

10. The Mine Creek Coal Company's shaft is located two

miles east of Pleasanton, on the Fort Madison branch of the Missouri Pacific railway.

11. The Pleasanton Coal Company's shaft is located one mile north of Pleasanton, on the Kansas City, Fort Scott & Memphis railway.

12. The A. F. Seright mine is located two and one-half miles east of Pleasanton; is not connected with any railroad.

13. The Sanson and Seright shaft is located two and one-half miles east of Pleasanton; is not connected with any railroad.

14. The Bradley-Vernon Company's mine, the only one at Boicourt, is connected with the Kansas City, Fort Scott & Memphis railway.

The coal stratum in the above mentioned localities is reached at a depth of 70 feet, except at Boicourt where it is reached at a depth of 90 feet. From Pleasanton east to the state line the coal comes close to the surface, while across the state line it outcrops at Moreland. East to and south of Moreland coal is mined by drifting. North of the Osage and along the railroad it is mined by drifting. The dip carries the coal under the Osage a short distance west of the state line. East of La Cygne the mining is conducted by shafting. The mines located in the vicinity of La Cygne are as follows:

15. The Ben Goode mine is located eight miles east of La Cygne and is not connected with the railroad.

16. The Gage Brothers' mine is located one-half mile east of Ben Goode's mine. It is not connected with the railroad.

17. The Orchard-Vantuyle mine is located six and one-half miles east of La Cygne and is not connected with the railroad.

18. The Enoch Sink shaft is located six miles east of La Cygne. It is not connected with any railroad.

Excepting in the vicinity of Prescott and in a large part of east Linn county, especially east of the railroad where coal is obtained in paying quantities by the strip pit process, most of the coal obtained from the localities just described is taken from shafts.

Lyon County.— Lyon county produces a little coal in the south-

eastern part. Here the coal is obtained by the strip pit process along the southern tributaries of the Marais des Cygnes, the area being the same as that already described for northeastern Greenwood county and northwestern Coffey county. In quality the coal is in no respect different from that obtained in those counties.

Montgomery County.— Montgomery county furnishes a little coal, the only mines opened being in the southeastern part of the county. At present they are all closed, due to the low price of coal shipped in from the large mines to the east.

Neosho County.— Neosho county, in the vicinity of Thayer, furnishes a comparatively large amount of coal for local consumption. The mines to the southwest of Thayer are operated principally in the winter and the coal hauled by wagon to Neodesha and other adjoining towns. The coal is obtained principally by drifting into the hillsides of the upper tributaries of Chetopa creek, particularly along Coal Hollow, the mining area extending westward into the edge of Wilson county.

1. Wilson's drift mine is located in Coal Hollow one-half mile north and two miles west of Thayer.

2. The Hight coal mine is located one and three-quarters miles west and one and one-half miles south of Thayer.

3. Several other mines were visited in this vicinity but the names of the owners were not obtained.

Osage County.— As a coal producer Osage county alternates with Leavenworth county for third rank in total output for the state. The coal in this county outcrops to the southeast and becomes buried beneath the surface to the northwest. Along the line of outcropping coal has been mined by the strip pit process from near the north side of the county north to Carbondale and southward to beyond Osage City. The Santa Fe railway passes near this line of outcropping on the north, but bears further west by way of Burlingame and Osage City to the south, at which points the coal is obtained at from 75 to 90 feet beneath the surface. Only a few rods to the west of a surface mine may be found a shaft which brings the coal from a greater depth,

the exact depth dependent upon the distance westward that the shaft is located. The following list gives the location of the principal mines:

1. The Osage Carbon Company's mine No. 25 is located one mile southeast of Osage City and is connected with the Santa Fe railway.

2. The Osage Carbon Company's shaft No. 27 is located about one mile southeast of Osage City and is connected with the Santa Fe railway.

3. The Western Fuel Company's shafts Nos. 2, 5, and 6 are located one and one-half and two miles east and one mile west, respectively, of Osage City. They are connected with the C. K. & W. branch of the Missouri Pacific railway.

4. The Black Diamond Coal Company's mine is located one and one-half miles east of Osage City and is connected with the C. K. & W. branch of the Missouri Pacific railway.

5. The Enterprise Coal Company's shaft No. 1 is located one and one-half miles east of Osage City. It is connected with the C. K. & W. branch of the Missouri Pacific railway.

6. The Matthew-Waddell mine is located one mile north of Osage City. It has no railroad connections.

7. The J. Johnson shaft is located one and one-half miles north of Osage City. It has no railroad connections.

8. A. W. Granstrom's mine is located one-half mile west of Osage City and is connected with the Missouri Pacific railway.

9. A. W. Granstrom's shaft No. 6 is located one mile west of Osage City. It has no railroad connections.

10. The Lloyd Brothers' drift is located in Osage City and is not connected with the railway.

11. The Murray Brothers' mine is located two miles east of Osage City and is not connected with the railway.

12. The Osage Carbon Company's mine No. 20 is located one mile northeast of Osage City and is connected with the Santa Fe railway.

13. The Osage Carbon Company's mine No. 22 is located in Osage City and is connected with the Santa Fe railway.

14. The Osage Carbon Company's shaft No. 23 is located one

mile northeast of Osage City and is connected with the Santa Fe railway.

15. The Osage Carbon Company's mine No. 24 is located one and one-half miles northeast of Osage City. It is connected with the Santa Fe railway.

16. The Osage Carbon Company's mine No. 6 is located one mile northeast of Peterton and is connected with the Santa Fe railway.

17. The Osage Carbon Company's shaft No. 9 is located at Peterton and is connected with the Santa Fe railway.

18. The Osage Carbon Company's mine No. 26 is located at Peterton and is connected with the Santa Fe railway.

19. The Coughlin Coal Company's mine is located one mile north and east of Peterton and is connected with the Santa Fe railway.

20. The Boruff coal mine is located one and one-half miles east of Peterton. Coal is hauled by wagon to the Santa Fe railway.

21. The Grant drift is located near Peterton. It is not connected with the railway.

22. The Sand Bank mine is located three-quarters of a mile south of Burlingame. It is not connected with the railway.

23. The Burlingame Coal Company's shaft No. 1 is located one-fourth of a mile east of the Santa Fe station at Burlingame and is connected with the Santa Fe railway.

24. The Star mine is located three miles south of Burlingame and is connected with the Santa Fe railway.

25. The Fair Ground mine is located on the fair ground at Burlingame and is connected with the Santa Fe railway.

26. The Cole and Burnett mine is located one mile south of the Santa Fe station at Burlingame and is connected with the same railway.

27. The Central Coal Company's mine is located one mile east of the station at Burlingame.

28. The Alliance mine is located two miles east of Burlingame. It is not connected with any railway.

29. The Boss coal mine is located two miles east of Burlingame and is connected with the Santa Fe railway.

30. The Ure shaft No. 1 is located three and one-half miles south of Burlingame and is not connected with the railway.

31. N. H. Lee's shaft is located one mile east of Burlingame and is not connected with the railway.

32. The Kansas Mining and Fuel Company's mine is located one and one-half miles north of Burlingame and is connected with the Santa Fe railway.

33. The Chappell Coal Company's mine No. 3 is located two miles east of Burlingame and is connected with the Santa Fe railway.

34. The Eureka mine is located two miles south of Burlingame. It is not connected with the railway.

35. The Champion mine is located three miles south and east of Burlingame. It is not connected with the railway.

36. The Turner Brothers' mine is located one and one-half miles south of Burlingame and has no railway connections.

37. The Osage Carbon Company's mine No. 10 is located at Scranton and is connected with the Santa Fe railway.

38. The Osage Carbon Company's shaft No. 12 is located one-half mile northeast of Scranton and is connected with the Santa Fe railway.

39. The Osage Carbon Company's mine No. 13 is located one mile east of Scranton and is connected with the Santa Fe railway.

40. The Chappell Coal Company's mine No. 2 is located one-half mile west of Scranton and is connected with the Santa Fe railway.

41. The Thomas Noble mine is located two miles northeast of Scranton. Coal is hauled by wagon to the Santa Fe railway.

42. The Ingham mine is located two and one-half miles southwest of Scranton and is connected with the Santa Fe railway.

43. The Belleville mine is located one mile west of Scranton and is connected with the Santa Fe railway.

44. The Ryan mine No 2 is located one and one-fourth miles

southeast of Scranton and is connected with the Santa Fe railway.

45. The Martin mine is located one and one-half miles southwest of Scranton. It is not connected with the railway.

46. The Chappell mine No. 1 is located one-half mile west of Scranton and is connected with the Santa Fe railway.

47. The Eagle slope is located one mile east of Carbondale and has no railroad connections.

Shawnee County.— The coals mined in Shawnee county probably belong to the same formation as those of Osage county but the coal stratum is a little thinner. There are two localities in Shawnee county where coal is now being mined, namely, at Topeka and Blacksmith. The exact location of the mines is as follows:

1. The Walwork mine is located three miles west on Tenth street at Topeka. Coal is hauled into the city by wagon.

2. Jim Bailey's shaft is located two and one-half miles west of Kansas avenue, on Sixth street.

3. The Crossdale mine is located about eight miles west of Topeka.

4. The McRoberts mine is located three miles west on Sixth street, Topeka.

5. The Capital strippings and drifts are located three and one-half miles south of Topeka.

6. The W. A. Eaton mine is located two miles west on Seventh street, Topeka.

7. At Blacksmith coal sufficient to supply a small local trade is mined.

Wabaunsee County.— A small amount of coal is produced in the eastern part of Wabaunsee county along the ravines of the tributaries of Mission creek, about half way between Keene and Dover. Here the coal varies from 6 to 12 inches in thickness and seems to belong to the same horizon as does the upper stratum of coal five or six miles west of Topeka, in the vicinity of Sugar Works. Coal has been mined particularly on the farms of Mr. Crane and Mr. Loomis.

Wilson County.— Wilson county produces but little coal, yet in the extreme eastern part of the county in the vicinity of Thayer the coal already described for Neosho county reaches across the line in some places into Wilson county. Also the southeastern part of the county has some beds of coal which seem to be largely independent of the Thayer coal beds. Here coal has been mined to a limited extent, but at present is abandoned on account of the difficulty in obtaining the coal in paying quantities.

THE CRETACEOUS AREA.

Passing westward from the Coal Measures area to the Cretaceous of the north-central part of the state it is found that here in the Dakota formations considerable Cretaceous coal exists and is now being mined in a number of counties and serves a good purpose in the way of supplying the local trade. Six counties in this vicinity have produced coal, namely: Cloud, Ellsworth, Lincoln, Mitchell, Republic, and Russell. The coal seems quite uniform in quantity and quality throughout the whole district.

In Cloud county the mining is principally conducted in the vicinity of Minersville, from five to eight miles north and a little east of Concordia. Here from five to eight different companies have been in operation, working a coal bed which is described as being from 20 to 22 inches thick and containing a fair quality of lignite.

In Ellsworth county the mines are located on Elkhorn creek in the northern part of the county and are described as containing coal 20 inches thick. The quality and quantity of the coal here is similar to that in Cloud county. A letter from Mr. Waterbury, of Wilson, to the State Mine Inspector, published in the Eighth Annual Report of the Inspector of Coal Mines, page 65, explains the mining situation there as follows:

"Owing to the coal getting thinner, faults, dikes, and other causes, this mine has steadily decreased in production for several years. There are five or six veins, but only three worth mentioning, and only two of these have been worked. The first or upper vein is about 3 inches thick; the next is about 4 feet lower, and varies in thickness from 8 to 20 inches; the next is from 4 to 14 feet lower, and runs from 4 to 12 inches thick. This is not worked much.

I am at present trying to open the lower vein. The rules for larger veins do not apply here. The coal is of an inferior quality. There are no regular hours for work. The men begin and quit when they please; there is no record of the day's work. The men get their own fuel for taking it out and there is no record of it kept. The mining industry is not likely to last long, as the coal gets thinner as we work south and the men cannot make living wages working it."

In Lincoln county coal is mined at Little Timber, Bacon, Rattlesnake, and Elkhorn creeks, and in the vicinity of Sylvan Grove, Vesper, Denmark, and Pittsburg, and is in every respect practically the same as that from the counties already mentioned.

The coal in Mitchell, Republic, and Russell counties is about the same as that already described for Cloud, Ellsworth, and Lincoln counties, with probably the smallest amount being mined from Russell.

DETAILED STRATIGRAPHY OF KANSAS COALS.

GENERAL OUTLINE OF THE STRATIGRAPHY.

The Coal Measures.

The Kansas coals occur in various shale beds, occupying all positions from the Cherokee shales at the base to the Osage shales more than 2000 feet above. In connection with the following descriptions the reader is referred to the generalized geologic section, Plate VI, and to the two maps, Plates VII and VIII.

The Cherokee shales produce vastly larger quantities of coal than any other shale beds in the whole Coal Measures. It is from this horizon that is obtained the coal of Cherokee and Crawford counties, the Fort Scott coal of Bourbon county, nearly all the coal of Labette county, and the coal of Leavenworth county. In addition to these localities it is known that coal could be obtained in other places. The deep borings at Cherryvale, in Montgomery county, show that a bed of coal from 26 to 28 inches in thickness lies near the base of the Cherokee shales at that place. Wells in the vicinity of Pleasanton likewise show that beneath the coal now operated and within the Cherokee shales other coal is found which sometimes may be operated to advantage. Other wells which have penetrated the Cherokee shales at various places within the state likewise show the same conditions, namely, that coal may be found in the Cherokee shales under a large part of southeastern and eastern Kansas. The abundance of coal within these shales seems to be so great that it need not be a surprise if heavy beds be found under any part of the eastern fifty or seventy-five miles of the state.

The Labette shales, first in order above the Cherokee shales,

have considerable bituminous matter within them, but nowhere does it amount to a good bed of coal. In a few places to the southwest of Fort Scott the coal is heavy enough so that it was formerly mined to a limited extent, but nowhere so far as is known have they produced any considerable amount.

The next shale bed above this, the Pleasanton shales, carries large quantities of coal, particularly in the Lower Pleasanton shales. This is true to so great an extent that a detailed description of the Pleasanton shales is given in the proper place. Suffice it here to say that next to the Cherokee shales the Pleasanton shales probably carry the largest amount of coal known in the state.

Above the Pleasanton shales the next important shale bed is that of the Thayer shales, a shale bed that likewise carries a considerable amount of coal. This is particularly true in the vicinity of Thayer and to the southwest between Thayer and Neodesha and Independence.

From the Thayer shales upwards the next important shale bed is the Lane shales which as far as is known, is void of coal.

Above this is found the Lawrence shales, a heavy bed carrying a sufficient amount of coal to be of great commercial importance. Coal is mined or has been in these shales in Atchison county at Atchison, in different places in Jefferson county, in scores of places in Douglas county, but most of all in Franklin county, to the west and southwest of Ottawa. Farther south they have produced coal in limited amounts throughout almost the whole area over which the Lawrence shales are exposed, to the southwest entirely to the south part of the state.

The various shale beds above the Lawrence shales seem to be barren of coal, or almost so, until the Osage shales are reached. Here is a formation averaging about 200 feet thick, extending entirely across the state from north to south and which carries a large amount of coal that has been mined in nearly a hundred places. In the northeastern part of the state to the northwest of Atchison a half dozen or more localities have furnished coal from these shales. Southward in the vicinity of Topeka

coal has been mined for years near the city and also further west near Sugar Works. And again southward, in the vicinity of Burlingame, Osage City, Carbondale, Scranton, etc., it has been mined to a great extent for more than twenty years. South from the Osage region, the same bed of shales has produced coal in the vicinity of Lebo, in Coffey county; Hilltop, and Virgil and other points in Greenwood county; at different places in Elk county; and at Leeds, in Chautauqua county. The coal of the Osage shales is not uniform in quantity or quality throughout this whole distance, but, it must be confessed, there is a strong similarity between the different samples found at the different places.

Above the Osage shales no coal has been found in the Carboniferous of Kansas of sufficient importance to justify mining, even for local consumption. At different places in the upper parts of the Coal Measures and also in a few places in the Permian rich carboniferous shales exist which somewhat resemble coal and which occasionally are locally called coal.

The only remaining coal in the state that need be noticed is the Cretaceous coal, found in the Dakota area of north central Kansas. The Dakota of Kansas has been divided by Logan[1] into two divisions, the "lower" and "upper," the division between the two being provisionally made the sandstone layer which immediately underlies the heavy bed of shale that is the coal producer. Logan's description of the stratigraphy of these western coals may be here included.[2]

The Upper Group.

"*Lignite Horizon.*—Resting upon the gray or white sandstone, in the last upper layer of the sandstone group, is a thin bed of lignite which is entirely wanting in certain localities. The lignite varies in thickness from 6 to 26 inches. In Republic county it occurs from 80 to 100 feet below the Benton limestone. In Lincoln county it is only 60 feet below that horizon, and in Russell county it is 90 feet. The thickest vein occurs in the mines on Little Timber creek in Lincoln county where the lignite rests between the beds of shale and gray sandstone, the shale adjacent the coal being extremely bituminous in character. In Republic county, near Minersville, two 9-inch veins are intercalated with shales which are argillaceous, and not bituminous in character. Above the

1. Logan: University Geological Survey of Kansas, vol. ii, p. 206, Lawrence, 1897.
2. Loc. cit., p. 208.

lignite bed in Mitchell county rests a thick bed of bituminous shales which seem to pass conformably into lignite. In Coal cañon thin layers of lignite are intercalated with sandstone and shale. The lignite is mined in this locality by tunneling into the drift of the creek bed. Shafts have been sunk to a depth of 80 feet in Republic county and 50 feet in Lincoln county. Lignite is mined and used for fuel in Republic, Mitchell, Lincoln, Russell, and Ellsworth counties. The lignite contains much ash in the form of pyrite, shale, etc. The principal mines are located on Wolf creek and Coal cañon in Russell county; on Coal creek and Elkhorn in Ellsworth county; on Spillman creek, Little Timber creek, Bacon creek, Rattlesnake creek, and Elkhorn creek in Lincoln county; on Rock creek and Solomon river in Mitchell county; on West creek in Republic and Cloud counties.

"The strata adjacent the lignite vary with the locality. In some localities the lignite rests between beds of shale, in others between layers of sandstone, and still in other localities it is found resting upon sandstone and covered with shale. In many places it is entirely wanting. Its place, however, may be occupied by a thin bed of bituminous shale."

The different coal-bearing horizons will now be considered more in detail, beginning at the base of the Coal Measures and progressing upwards.

CHEROKEE SHALES.

The position, areal extent, and general characteristics of the Cherokee shales have been given in considerable detail in the first part of this volume, to which the reader is referred in this connection.

Of all coal-bearing horizons in the state the Cherokee shales are by far the most important, as they have produced more than three-fourths of all the coal that has thus far been mined in Kansas. They occupy large surface areas in both Cherokee and Crawford counties and lesser areas in Labette and Bourbon counties. In addition to this they pass westward and northward under the overlying strata to unknown distances, and throughout a considerable part of this westward extension they are known to carry coal. It is impossible to make any definite statement regarding the amount and position of this deeply buried coal. It is mined extensively at Leavenworth, and has been reached by scores of wells drilled in prospecting for oil and gas. The coal map, Plate VIII, shows in detail the surface area covered by the Cherokee shales and how they pass west-

ward under the overlying formations. Also the gradual decrease westward of the shading illustrates the decreasing probability of finding coal in the Cherokee shales which are there covered by succeeding strata.

It is no vain statement that from every standpoint of geology there is a possibility of finding coal in this covered area. Had not enterprising prospectors sunk the deep wells at Leavenworth we would be in ignorance of the coal at that place. There is just as much reason *a priori* for looking for coal in the Cherokee shales anywhere to the east of the outcropping of the Oread limestone as there was at Leavenworth, and no one need be surprised at any time should prospecting develop such coal. Already the well record at Cherryvale shows that the coal exists there in as great quantity as it does at Leavenworth and it need be no surprise if dozens of other localities are found where similar quantities may be had.

With the known amount of coal in the Cherokee shales and with the probability of finding other amounts likewise, as just stated, we must look upon them as being one of the greatest coal producing horizons in the Mississippi valley.

For a more detailed account of the Cherokee shales the following extracts are taken from the records of the various deep wells that have gone into or through them :

Weir City Water Well.

Reported by A. B. COCKERILL, Manager Cherokee-Lanyon Spelter Company.

MATERIAL.	Thickness of Coal.	Thickness of Strata.	Depth to Bottom of Strata.
Soil and Clay	....	15 feet	15 feet.
Sandstone	....	5 "	20 "
Shale	....	10 "	30 "
Coal	36 inches.	3 "	33 "
Fire Clay	....	3 "	36 "
Shale	....	75 "	111 "
Coal	14 inches.	1 foot 2 inches.	112 " 2 inches.
Fire Clay	....	2 feet	114 " 2 "
Shale	....	100 "	214 " 2 "
Coal	24 inches.	2 "	216 " 2 "
Fire Clay	....	2 "	218 " 2 "
Shale	....	62 "	280 " 2 "

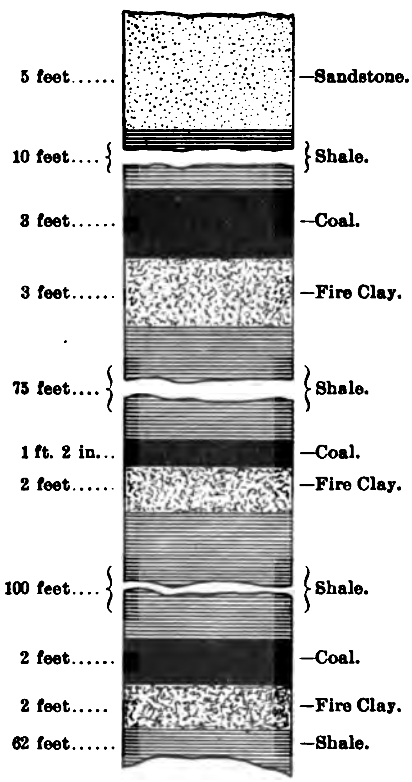


FIGURE 4. Section of Weir City Well.

Well near Pittsburg.

Reported by Prof. O. St. John.

Material.	Thickness of Coal.	Thickness of Strata.	Depth to Bottom of Strata.
Soil and Yellow Clay		5 feet	5 feet
Soft Drab Shales		10 " 5 inches	15 " 5 inches.
Dark Drab Shales		3 " 7 "	19 "
Black Shales		5 " 8 "	24 " 8 "
Coal	9 inches.	9 "	25 " 5 "
Soft, Light, Drab Clay		11 "	26 " 4 "
Limestone		2 " 4 "	28 " 8 "
Black Shales		2 " 9 "	31 " 5 "
Limestone		8 "	32 " 1 "
Black Shales		2 " 8 "	34 " 9 "
Limestone		11 "	35 " 8 "
Black Shales		1 " 6 "	37 " 2 "
Drab Clay Shales		5 " 6 "	42 " 8 "
Coal	4 inches.	4 "	43 "
Drab Clay		1 " 2 "	44 " 2 "
Coal	5 inches.	5 "	44 " 7 "
Light Drab Clay		6 " 11 "	51 " 6 "
Light Drab Gritty Shales		9 " 8 "	61 " 2 "
Soft Blue Shales		4 "	65 " 2 "
Black Shales		3 " 7 inches	68 " 9 "
Dark Calcareous Band		5 "	69 " 2 "
Coal	20 inches.	1 " 8 "	70 " 10 "
Light Drab Clay		2 " 4 "	73 " 2 "
Hard Gray Sandstone		1 " 2 "	74 " 4 "
Drab, Slightly Gritty, Shales		7 " 8 "	82 "
Drab Clay Shales		4 "	86 "
Soft Blue Shales		1 " 6 inches	87 " 6 inches.
Limestone		7 "	88 " 1 "
Black Shales		6 "	88 " 7 "
Coal	9 inches.	9 "	89 " 4 "
Light Drab Clay		1 " 10 "	91 " 2 "
Drab, Gritty Shales		10 "	92 "
Compact, Gray, Sandy Shales		7 " 10 "	99 " 10 "
Dark Clay Shales		2 " 6 "	102 " 4 "
Gray, Coarse, Gritty Shales		6 " 6 "	108 " 10 "
Dark, Drab, Slightly Gritty Shales,		2 " 6 "	111 " 4 "
Compact, Drab, Gritty Shales		1 " 6 "	112 " 10 "
Soft, Dark, Drab, Shales		1 " 3 "	114 " 1 "
Dark Blue Shales		2 " 4 "	116 " 5 "
Limestone		5 "	116 " 10 "
Black Shales		2 " 2 "	119 "
Coal	3 inches.	3 "	119 " 3 "
Drab, Gritty Shales		10 "	120 " 1 "
Drab, Fine Gritty Shales		6 "	126 " 1 "
Hard Gray Sandstone		1 " 4 inches	127 " 5 "
Gray, Sandy Shales		9 "	136 " 5 "
Drab, Coarse, Gritty Shales		2 " 10 inches	139 " 3 "
Gray, Sandy Shales, Coal Streaks		5 " 10 "	145 " 1 "
Gray, Coarse Gritty Shales		1 " 1 "	146 " 2 "
Soft Drab Shales		3 "	146 " 5 "
Coal	39 inches.	3 " 3 "	149 " 8 "
Gray, Gritty Clay		3 "	149 " 11 "
Soft, Dark Drab, Clay		1 " 1 "	151 "
Dark Blue Clay with Coal Streaks,		8 "	151 " 8 "
Light Drab Clay		4 "	152 "

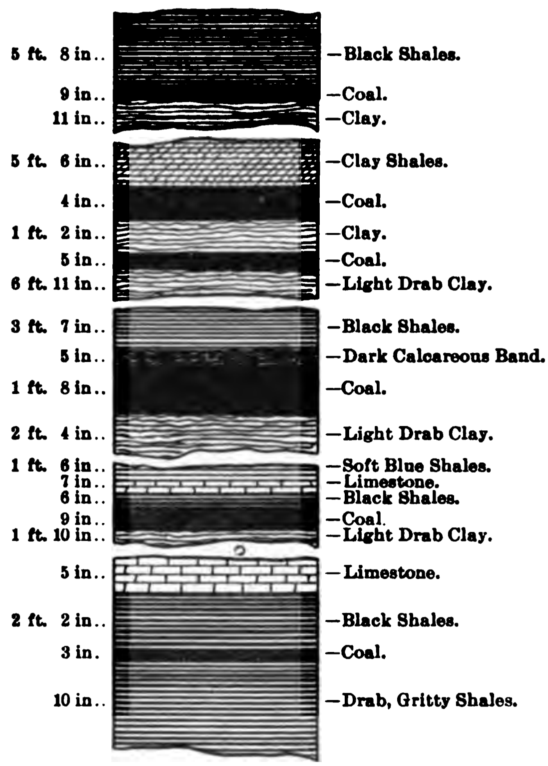


FIGURE 5. Section of Well near Pittsburg.

McKee's Gas Well, North of Girard.

MATERIAL. Beginning at 148 feet.	Thickness of Coal.	Thickness of Strata.	Depth to Bottom of Strata.
Black Shale		5 feet	153 feet.
Brown Limestone		2 "	155 "
Oil Sand		5 "	160 "
Sand Shale		55 "	215 "
White Shale		33 "	248 "
Brown Shale		10 "	258 "
Brown Limestone		4 "	262 "
Shale		2 "	264 "
Limestone		3 "	267 "
Shale		2 "	269 "
Limestone		3 "	272 "
Shale		52 "	325 "
Sandstone		7 "	332 "
Shale		26 "	358 "
Black Shale		2 "	360 "
Lime Shale		3 "	363 "
White Shale		17 "	380 "
Brown Shale		30 "	410 "
Alternate Light and Dark Shale		79 "	489 "
Sand and Little Gas		3 "	492 "
Shale		4 "	496 "
Alternate Sandstone and Shale		13 "	509 "
Sandstone		6 "	515 "
Black Shale, Little Coal		3 "	518 "
Dark Shale		32 "	550 "
Total		402 feet.	

La Harpe Well.

Reported by L. C. BEATTIE, Manager Palmer Oil Company.

MATERIAL. Beginning at 637 feet.	Thickness of Coal.	Thickness of Strata.	Depth to Bottom of Strata.
Gray Shale		5 feet	642 feet.
Gray Sandstone		8 "	650 "
Gray Shale		8 "	658 "
Dark Shale		6 "	664 "
Red Flint and Limestone		3 "	667 "
Black Shelly Sandstone		10 "	677 "
Dark Shale		26 "	703 "
Changeable Shale; Light, Dark, Green, Black		192 "	895 "
Sand Shale, with some Clear Sand,		12 "	907 "
Black Shale		6 "	913 "
Dark Sand Shale		8 "	921 "
Black Shale		61 "	982 "
Total		345 feet.	

Girard Well. No. 1.

MATERIAL. Beginning at 54 feet.	Thickness of Coal.	Thickness of Strata.	Depth to Bottom of Strata.
Soapstone Shale		104 feet	158 feet.
Limestone		11 "	169 "
Black Slate Shale		4 "	173 "
Soapstone Shale		130 "	303 "
Sand Shale		97 "	400 "
Soapstone Shale		75 "	475 "
Coarse Sandstone		25 "	500 "
Total		446 feet.	

Humboldt Well. No. 1.

Reported by GUFFEY & GALEY. Location: Section 8, township 26 south, range 18 east.

MATERIAL. Beginning at 635 feet.	Thickness of Coal.	Thickness of Strata.	Depth to Bottom of Strata.
Shale—Water bearing		10 feet	645 feet.
White Shale		30 "	675 "
Black Shale		70 "	745 "
White Shale		15 "	760 "
Black Shale		36 "	796 "
Sandstone		2 "	798 "
Black Shale		96 "	894 "
Sandstone		5 "	899 "
Shale		46 "	945 "
Sandstone—Salt Water bearing		25 "	970 "
Total		335 feet.	

Humboldt Well. No. 5.

Location: Northeast quarter of northwest quarter, section 29, township 25 south, range 18 east.

MATERIAL. Beginning at 650 feet.	Thickness of Coal.	Thickness of Strata.	Depth to Bottom of Strata.
Shale		15 feet	665 feet.
Shale		147 "	812 "
Sandstone		4 "	816 "
Shale		62 "	878 "
Sandstone		47 "	925 "
Break, White Sandstone and Shale,		17 "	937 "
Total		287 feet.	

Toronto Well.

Reported by Mr. TROXEL.

MATERIAL. Beginning at 1,080 feet.	Thickness of Coal.	Thickness of Strata.	Depth to Bottom of Strata.
Dark Shale		24 feet	1,104 feet.
Oil Sand		25 "	1,129 "
Shale		11 "	1,140 "
Shale		110 "	1,250 "
Soft Sandstone		4 "	1,254 "
Shale		86 "	1,340 "
Soft Sandstone		7 "	1,347 "
Shale		83 "	1,430 "
Soft Sandstone		8 "	1,438 "
Shale		14 "	1,452 "
Total		372 feet.	

Pleasanton Well.

Location: Section 25, township 21 south, range 24 east.

MATERIAL. Beginning at 214 feet.	Thickness of Coal.	Thickness of Strata.	Depth to Bottom of Strata.
Shale	....	74 feet	288 feet.
Shale and Sandstone	....	20 "	302 "
Sandstone	....	8 "	316 "
Black Shale	....	22 "	338 "
Shale—Water-Bearing	....	10 "	348 "
Brown Sandstone	....	5 "	553 "
White Shale	....	5 "	358 "
Black Shale	....	40 "	398 "
Black Sandstone	....	26 "	424 "
White Sandstone	....	20 "	444 "
White Shale	....	95 "	539 "
Black Shale	....	117 "	656 "
Sandstone and Limestone (?)	....	30 "	686 "
Sandstone	....	6 "	692 "
Shale and Sandstone	....	65 "	757 "
Total	....	543 feet.	

Coal Beds in the Cherokee Shales.

The Cherokee shales have coal at different positions within them. These positions vary both vertically and horizontally. In some localities coal exists near the base. In the southeastern part of Cherokee county coal has been found only a few feet above the base of the shales. This coal, however, is thin and of little commercial importance. A few farmers mined it years ago to supply their own fires, but beyond this it has never been developed. In the latter 'sixties coal was mined by stripping in different places on the west side of Brush creek in Cherokee county. Here the coal was heavier than that just mentioned, but was still too light to support mines for commercial purposes. In the early days of the settlement of the country coal was teamed from these mines to the neighboring villages and to a limited extent into Missouri. But of recent years the mines have been entirely abandoned.

Next above this coal is a horizon which still furnishes a considerable quantity of coal for the general markets, particularly when a combination of events favors a slight advance in prices. It lies about 150 feet above the base of the shales. It is capped by a thin layer of shale which in turn rests immediately under a heavy sandstone — the Columbus sandstone — which covers so large an area to the east and southeast of Columbus. Here

over an area of many square miles the coal is found outcropping along the bluffs of Brush creek and Shawnee creek and other lesser tributaries, reaching all the way from within a mile of Columbus eastward to the escarpments facing Crestline and the valley to the south. This coal horizon seems not to extend very far west of Columbus, at least its absence is known in many places where wells have penetrated the shales a sufficient depth to have reached it.

THE WEIR-PITTSBURG BEDS.

Above the Columbus coal lie the Weir-Pittsburg Lower and Upper coals which are the heaviest known in the state, the Lower averaging about 40 inches and the Upper about 30 inches in thickness. The outcroppings of these coal beds form an irregular line extending northeast and southwest by way of Stippville, Scammon, Weir City, Pittsburg, and other points to the northeast.

Development of the Weir-Pittsburg Coals.—In 1868, after the sale to the James F. Joy Company of the "Cherokee neutral lands," as they were then called—an area twenty-five by fifty miles in the southeastern part of the state including all of Cherokee and Crawford counties and the south part of Bourbon county—Professor Wilbur of Chicago was sent out by a Chicago company to examine the lands for coal. He reported that coal existed in large quantities along a narrow strip of country from Pittsburg to Weir and farther to the southwest. In some places he found the coal to be about four feet thick, but elsewhere much thinner.

Previous to this time the early settlers had mined coal from the Weir-Pittsburg Lower and Upper beds at a half dozen or more localities. It seems that before the civil war, back in the 'fifties, coal was mined to a limited extent from the Weir-Pittsburg Lower bed by citizens of Missouri who teamed it to Granby and other places where it was used for blacksmithing. During the autumn of 1866 a blacksmith from Granby came over and obtained the assistance of Mr. W. H. Peters, a citizen of the southeast part of Cherokee county and at present a member of

the board of county commissioners. The blacksmith led the way to an outcropping of the Weir-Pittsburg Lower at a point near the present eastern suburbs of Weir City. Here with almost no labor at all they stripped a little soil from the upper surface of the coal and loaded their wagons rapidly by the use of pick and shovel. Later in the same autumn Mr. Peters with other neighbors revisited the locality and obtained coal in a similar manner. At that date the wide prairie land between Spring river and Neosho river was not occupied by settlers, so that coal was obtained nearly ten miles from the nearest residence. As the settlements pushed farther west during the summer of 1867 and '68 the coal mining likewise was increased, so that by the time Professor Wilbur visited the area he had the assistance of the partially developed mines to direct his investigations.

Shortly after the Missouri River, Fort Scott & Gulf railroad, now the Kansas City, Fort Scott & Memphis, completed its line to Baxter Springs in 1870, a coal company was formed in Fort Scott for the purpose of mining coal which was sold principally to the railroad company. Mining operations were conducted in the vicinity of Fort Scott and on the Drywood to the south, as elsewhere explained, and also by the same company along the outcroppings of the Weir-Pittsburg Lower in the vicinity of Stilson, now Scammon, from which point coal was teamed to the different railroad stations to supply the demands of the road and for shipment into the general market. The Fort Scott company operated for about two years when it quit the business. During this time a large number of individuals began mining operations at various places by the strip pit process so that in the aggregate a considerable quantity of coal was shipped into the market.

In 1874 Scammon Brothers sank a shaft just north of the old town of Stilson, now Scammon, from which shaft large quantities of coal were obtained. There was considerable opposition to this enterprise by their friends who doubted the expediency of such a method of mining, fearing that the nearness to the surface would cause the roof to break and crumble to such an

extent that mining by the room and pillar system could not be employed. But the firm of Scammon Brothers persevered and from the start succeeded admirably, both mechanically and financially. From a shaft which began with two or three car loads a day they soon had it developed to a capacity of forty cars a day. Upon the success of this new method of mining others imitated them and shafts were sunk in many localities until the development of today was reached.

In 1871 the firm of Keith & Rawlings, of Kansas City, began dealing in coal and conducted their operations so that they were of great assistance in the development of mining property. After the death of Mr. Rawlings Mr. Keith was associated with a second partner by the name of Borard. In 1872 they began mining by the strip pit process and shipping coal to Kansas City and other markets, as well as supplying the railroad with large quantities of it. Later Mr. Keith was associated with a Mr. Henry, and in 1880 the firm of Keith & Perry was formed, a company which perhaps has exerted as wide an influence on coal mining in Kansas as any other company, largely because they were pioneers in the business.

In 1878 and 1879 Moffet and Sargent, of Joplin, Missouri, built the Joplin & Girard railroad from Joplin to Pittsburg, primarily for the purpose of obtaining coal from the Kansas fields. The city of Pittsburg originated with the road and was purely a coal mining town until the zinc smelters were established there later. It was in 1878 also that the Kansas and Texas Coal Company began their operations in a small way at Weir. Here from a beginning of operating coal mines by the strip pit method on a small scale this company has grown into one of the strongest in the territory. The Santa Fe Company, now changed to the Mount Carmel Coal Mining Company, did not obtain a foothold in these coal fields until March, 1886, and the Missouri, Kansas & Texas Railway Company did not get its mines started at Mineral City until 1895.

In 1897 Cherokee and Crawford counties produced 2,652,029 tons of coal, giving employment to 5540 men part of the year.

These figures include the production from the Arcadia area as well as that from the Weir-Pittsburg beds.

The first mining that was done on this Weir-Pittsburg horizon in the early 'seventies was confined to the strip pit processes and therefore the principal mining towns were located along the irregular line of outcropping previously mentioned. As the coal dips to the northwest at a low angle it may be reached by shafting to various depths, dependent upon the distance back from the line of outcropping, and upon the general contour of the surface.

Mining developments have now been carried far enough to determine the extent of this heavy coal with a tolerable degree of accuracy. It is found that it is limited in extent to the southwest so that it reaches a point opposite Columbus, while to the northwest in transverse direction it does not reach as far as Girard. It therefore is a long elliptical area with the major axis trending northeast and southwest. From the central area the coals gradually grow thinner in every direction.

The extreme southwestern limit, however, is not yet known. Only a few years ago it was thought that the ridge along the line of the Missouri Pacific railroad between Cherokee and Sherwin Junction limited the western extent of these coals. At present, however, it is known that there is a large quantity of coal in the vicinity of Mineral where the M. K. & T. Railroad Company has its mines. Beyond Mineral to the west, northwest, and southwest the limitations are not yet fully determined.

Further to the southwest in the vicinity of Oswego there is a varying amount of coal at about the same horizon as the Weir-Pittsburg coal, although a definite connection between the two areas has not been made. The Oswego coal is by no means so heavy, the thickest bed being from 18 to 24 inches.

COAL ABOVE THE WEIR-PITTSBURG.

Above the two Weir-Pittsburg horizons are other lesser beds of coal, the outcropping lines of which are farther to the northwest. At some places it would seem there is but one of these,

while in others there appear to be two. They are found in northwestern Cherokee county on the east side of Lightning creek, and to a less extent in southwestern Crawford county, and also farther to the northeast towards the state line.

Still higher, at the very summit of the Cherokee shales, is another coal bed which has produced large quantities of coal for the market and has therefore performed an important part in the history of coal mining in the state. This is generally known as the Fort Scott coal. It lies from 6 to 10 feet below the lower member of the Oswego limestone system. In the vicinity of Fort Scott these limestones are cut through by the Marmaton river and by all of its many tributaries. South from Fort Scott the upper tributaries of the Drywood likewise cut through the Oswego limestones in many places. Throughout all of this area, making many miles in linear extent, the Fort Scott coal outcrops along the banks and bluffs of these various streams and drainage channels. It has been extensively mined, but always by the strip pit process. As the overlying limestone is heavy and difficult to remove the stripping never has been carried back very far from the front surface — the coal thus obtained therefore always has been exposed to the weathering agents and the pyrite it contains has been oxidized into iron rust, giving a reddish color to the coal. In this way the coal from this whole area has been known in the markets as the Fort Scott "red" coal.

The Leavenworth coal is found in the Cherokee shales. It seems that here three horizons exist, the lower one at a depth of 988 feet below the surface, the middle one at 748 feet, and the upper one 720 feet. Each of these three is reported to be a 24 inch bed of coal. It is the upper one that is mined at the present time. If the published drill records can be relied upon either of the other beds would be almost as profitable as the one now mined. Any attempt at correlations between the Leavenworth coals and the coals of Cherokee and Crawford counties would be largely conjectural further than to show that they all belong to the Cherokee shales. The lowermost coal, the one at

988 feet below the surface, is 157 feet above the base of the Cherokee shales, which would place it at about the same position as the Columbus coals already described. The middle horizon is 398 feet above the base of the shales, and the upper one, the one now mined, 425 feet above the base of the shales. It manifestly would be improper to look upon these as an extension of the southern coal beds, but rather it should be considered that during the formation of the Cherokee shales physical conditions were favorable for the production of coal here and there at irregular intervals throughout a wide area and that the southern coals were formed in one basin and the Leavenworth coals in another, with an indefinite number of intermediate areas probably existing.

Weir-Pittsburg Area.

Returning now to Cherokee and Crawford counties it may be well to examine the mining territory in more detail.

The two strata of coal known as the Weir-Pittsburg Upper and Lower furnish the greater part of the workable coal of the state. A third stratum makes its appearance between the Upper and Lower and will be called the Intermediate.

The Lower stratum is the thickest and is the one most worked. It is worked at a depth of about 90 feet in the northern part of the county. In the western part the same stratum is worked at a depth of 230 feet, in the central portion it is reached at a depth of 70 to 80 feet, while in the south-central part the same coal is met with at 25 feet from the surface.

The Upper stratum of the Weir-Pittsburg coal is reached at a depth of 96 feet in the western part of the county; in the northern part it is worked at about 50 or 60 feet on the average; in the west-central part it is passed through at a depth of 15 or 20 feet; and in the southern part no trace of the stratum is to be found. The line of outcropping of this stratum lies west of Weir City, passing to the south and west, while on the north it follows quite closely a line parallel to the outcropping of the Lower, maintaining an average vertical distance of 30 feet above it. The line of outcropping of these two strata of

coal cannot be traced continuously throughout the county, due to the fact that the covering is shale, which weathers into soil so readily that the coal strata in most cases are covered up. To reach the Weir-Pittsburg coal in the northern part of the county a vertical distance of at least 270 feet would have to be passed through.

MINERAL CITY AND VICINITY.

The lowest coal stratum is reached at a depth of 229½ feet at the southeast corner of the northwest quarter of the southwest quarter of section 9, township 31, range 23, about five miles north of Mineral City. It is 32 inches in thickness, good coal, roofed by 19½ feet of black, bituminous shale, and underlaid by 14 inches of fire clay. A drill hole here shows the following association of strata:

A.—*Record of Drill Hole Five Miles North of Mineral City.*

MATERIAL.	Thickness of Coal.	Thickness of Strata.	Depth to Bottom of Strata.
Soil and Clay		12 feet	12 feet.
Clay and Gravel		27 " 4 inches.	39 " 4 inches.
Gray Shale		5 " 4 "	44 " 8 "
Coal	16 inches.	1 " 4 "	46 "
Fire Clay		2 "	48 "
Gray Shale		5 "	53 "
Black Shale		14 " 6 inches.	67 " 6 inches.
Coal	34 inches.	2 " 10 "	70 " 4 "
Fire Clay		2 " 2 "	72 " 6 "
Drab Shale		9 " 1 "	81 " 7 "
Coal	15 inches.	1 " 3 "	82 " 10 "
Fire Clay		4 " 2 "	87 "
Sandstone		4 "	91 "
Gray Shale		5 " 7 inches.	96 " 7 inches.
Coal	25 inches.	2 " 1 "	98 " 8 "
Fire Clay, soft		2 " 8 "	101 " 4 "
Drab Shale		16 " 8 "	118 "
Coal	9 inches.	9 "	118 " 9 "
(?)		2 " 9 "	121 " 6 "
Gray Shale		33 " 6 "	155 "
Black Jack		4 " 6 "	159 " 6 "
Coal	11 inches.	11 "	160 " 5 "
Gray Shale		17 " 7 "	178 "
Coal	41 inches.	3 " 5 "	181 " 5 "
Black Shale		1 " 5 "	182 " 10 "
Coal	4 inches.	4 "	183 " 2 "
Fire Clay		1 " 7 "	184 " 9 "
Gray Shale		8 " 3 "	193 "
Black Shale		8 " 2 "	201 " 2 "
Coal	12 inches.	1 "	202 " 2 "
Gray Shale		7 " 10 inches.	210 "
Black Shale		19 " 6 "	229 " 6 "
Coal	32 inches.	2 " 8 "	232 " 2 "
Fire Clay			

The same stratum was passed through by a drill 400 feet south and 528 feet west of the northeast corner of the northwest

quarter of the northeast quarter of section 24, township 31, range 23. The following is a record of the prospect hole:

B.—*Record of a Prospect Hole near Mineral City.*

MATERIAL.	Thickness of Coal.	Thickness of Strata.	Depth to Bottom of Strata.
Clay and Shale	....	7 feet 7 inches.	7 feet 7 inches.
Coal	11 inches.	11 "	8 " 6 "
Gray Shale	....	10 "	9 " 4 "
Sandstone	....	6 feet 3 "	15 " 7 "
Black Shale	....	14 " 7 "	30 " 2 "
Coal	24 inches.	2 "	32 " 2 "
Fire Clay, soft	....	5 " 5 inches.	37 " 7 "
Drab Shale	....	6 " 5 "	44 "
Gray Shale	....	6 " 10 "	50 " 10 "
Drab Shale	....	10 "	60 " 10 "
Coal	8 inches.	8 inches.	61 " 6 "
Fire Clay	....	2 " 6 "	64 "
Gray Shale	....	4 " 10 "	68 " 10 "
Sandstone	....	4 " 6 "	73 " 4 "
Gray Shale	....	5 " 2 "	78 " 6 "
Drab Shale	....	21 " 4 "	99 " 10 "
Gray Shale, hard	....	22 " 4 "	122 " 2 "
Coal	47 inches.	3 " 11 "	126 " 1 "
Black Bituminous Clay	....	2 "	126 " 3 "

By comparing these records we see that the black shale roof of the first has changed to a gray shale in the second, which makes a somewhat better roof than the bituminous shale; the fire clay floor of the former has also been replaced by bituminous clay. The coal found in these borings is of fairly good quality and of uniform thickness, but has considerable "black jack" (bituminous shale) and sulphur in the form of pyrite. "Horsebacks" are quite numerous here, but are found most abundant at Mineral City, at which place much of the coal is rendered worthless by the frequent crossing and recrossing of "horsebacks" and, in many instances, the complete cutting out of the coal by them. Ten strata of coal were passed through in the 232 feet drilled, as seen in the record. These vary in thickness from 4 to 41 inches. In the thinner strata the coal merges into bituminous shale. The exceedingly large number of coal strata with accompanying shale shows how very carbonaceous the shales are in this locality. The sandstone and arenaceous shales met with are very characteristic of the Cherokee shales as found further east.

The Upper and Lower strata are represented in A at 96 feet 7 inches and 229 feet 6 inches, respectively, and in B only the

Upper was reached, which was found at 122 feet 2 inches. In consequence of the westward dip the Lower stratum lies much deeper at this point. Deeper drilling here—regarding the dip of the strata as uniform—would result in finding the Lower at a depth of 250 odd feet. From both A and B we see a third coal stratum making its appearance at 67 feet 6 inches and 30 feet 2 inches, respectively, from the surface, or at an average of 60 feet above the Upper. One 40-inch stratum appears between the Upper and Lower.

VICINITY OF M'CUNE.

Passing a short distance northwest to McCune, we find a shaft which was sunk here ten or twelve years ago, but which has not been in operation for several years. No detailed record of the shaft is obtainable, but the following general record shows the position of the coal passed through:

C.—*Record of Coal Strata in a Shaft at McCune.*

MATERIAL.	Thickness of Coal.	Thickness of Strata.	Depth to Bottom of Strata.
Coal	18 inches.		85 feet.
"	24 "		125 "
"	12 "		155 "
"	12 "		185 "
"	12 "		215 "
"	6 "		333 "
"	14 "		400 "
"	10 "		

According to this record we find eight distinct coal strata in the 400 feet passed through, only one of which strata is of sufficient thickness to warrant mining.

The Upper stratum, as it dips 12 feet to the mile, would be in the neighborhood of 200 feet from the surface at this point. The 24 inch stratum of this record, placed at 125 feet, might possibly be the Upper. The Lower, dipping westward 20 feet to the mile, ought to be found at this point about 350 to 400 feet below the surface. The 14 inch stratum of the above record, at 400 feet, comes the nearest to correlating with the Lower. The extreme thinness might be accounted for by local alteration in the stratum.

Passing east to Cherokee we find a shaft 150 feet deep. The Upper and Lower are quite prominent here. The Upper is reached at 40 feet, showing a 20 to 24 inch stratum; at 150 feet the Lower stratum was reached. The Lower stratum is said to be 36 inches in thickness, but varies from 30 to 48 inches. The coal is of excellent quality with very little or no bituminous shale ("black jack") either above or below. "Horsebacks" are present but not numerous. The amount of "sulphur" found in the coal is probably considerably below the average of the coal of the Cherokee shales. A few fossil invertebrates and plants are found. The dip is to the northwest.

STIPPVILLE.

About five miles north of Columbus, at Stippville, the first shaft is met with in passing northward into the coal mining regions. Here the coal is 4 feet thick and lies 20 feet below the surface. It is the Weir-Pittsburg Lower and is of extra good quality. The mine was closed when last visited—during the summer of 1897. Two or three miles north of Stippville, on the Perry farm, which is two and one-half miles south of Scammon, on the northwest forty of the quarter section, a prospect drill hole has been sunk, the record of which is as follows:

D.—*Record of a Drill Hole near Stippville.*

MATERIAL.	Thickness of Coal.	Thickness of Strata.	Depth to Bottom of Strata.
Soil and Clay	....	8 feet.	8 feet.
Shale	....	1 " 6 inches.	9 " 6 inches.
Coal Blossom	6 inches.	6 "	10 "
Fire Clay	....	2 "	12 "
Sandy Fire Clay	....	6 "	18 "
Shale	....	2 " 6 inches.	20 " 6 inches.
Sandstone	....	5 " 3 "	25 " 9 "
Ironstone	....	2 "	25 " 11 "
Sandstone	....	1 " 1 "	27 "
Sandy Shale	....	4 "	32 "
Blue Shale, soft	....	1 "	33 "
Blue Shale	....	1 "	34 "
Shale, pyritiferous	....	8 inches.	34 " 8 inches.
Coal	41 inches.	3 " 5 "	38 " 1 "

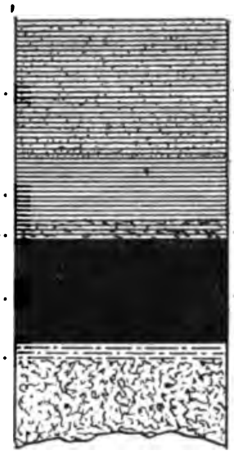


FIGURE 6. Section of Well South of Scammon, on Perry Farm.

On the same farm, in the center of the south half, is another prospecting drill hole, which gives the following section:

E.—*Record of a Drill Hole near Stippville.*

MATERIAL.	Thickness of Coal.	Thickness of Strata.	Depth to Bottom of Strata.
Soil and Clay	....	9 feet.............	9 feet.
Sandstone	....	6 "	15 "
Streaks of Sand and Shale	....	7 " 6 inches.	22 " 6 inches.
Soft Blue Shale	....	1 " 7 "	24 " 1 "
Hard Blue Shale	....	1 " 1 "	25 " 2 "
Coal	45 inches.	3 " 9 "	28 " 11 "

The coal reached here at 34 feet 8 inches and at 25 feet 2 inches in D and E respectively is of the same quality as that found at Stippville. The roofing of the former is pyritiferous shale, which makes a fairly good roof, in the latter a good working roof of hard blue shale is found. The floor is a good quality of fire clay. "Horsebacks" occur occasionally. Sulphur in the form of balls and thin laminæ of pyrite in the coal is often met with. The workable stratum found here is the Lower.

A stratum intermediate between the Upper and the Lower averaging 6 inches in thickness is passed through here in D,

just on the southeast limit, the "blossom" being reached at a depth of 9 feet 6 inches. In E a short distance to the south of D no trace of this "blossom" is found.

SCAMMON AND VICINITY.

Two prospecting drill holes on the Scammon farm, designated here as F and G respectively, give the depth of coals with accompanying strata as passed through in shaft No. 7, northeast quarter of section 4, township 32, range 24.

F.—*Record of a Drill Hole at Scammon.*

MATERIAL.	Thickness of Coal.	Thickness of Strata.	Depth to Bottom of Strata.
Clay and Soil		12 feet	12 feet.
Shale		4 "	16 "
Coal	12 inches.	1 "	17 "
Fire Clay and Shale		13 "	30 "
Gray Shale		13 "	43 "
Sandstone		3 inches.	43 " 3 inches.
Blue Shale		5 " 6 "	48 " 9 "
Sandstone and Ironstone		1 " 3 "	50 "
Blue Shale		1 " 6 "	51 " 6 "
Coal	6 inches.	6 "	52 "
Fire Clay		8 "	60 "
Sandy Shale, gray		15 "	75 "
Sandy Shale		5 " 6 inches.	80 " 6 inches.
Coal	6 inches.	6 "	81 " 6 "
Sandstone, gray		1 " 9½ "	82 " 9½ "
Coal	13⅛ inches.	1 " 1⅛ "	83 " 1⅛ "

The second well, G, located about 300 feet southwest of the shaft, shows the following sequence of strata:

G.—*Record of Drill Hole at Scammon.*

MATERIAL.	Thickness of Coal.	Thickness of Strata.	Depth to Bottom of Strata.
Soil and Clay		11 feet	11 feet.
Shale		2 "	13 "
Coal	6 inches.	6 inches.	13 " 6 inches.
Fire Clay		3 "	16 " 6 "
Sandstone		2 " 6 inches.	19 "
Shale		6 "	25 "
Shale, gray		15 " 11 inches.	40 " 11 inches.
Sandstone		1 "	41 "
Blue Shale		6 "	41 " 6 "
Ironstone		2 "	41 " 8 "
Blue Shale		3 feet 10 "	45 " 6 "
Ironstone		5 "	45 " 11 "
Blue Shale		6 "	46 " 5 "
Ironstone		5 "	46 " 10 "
Blue Shale		1 foot 6 "	48 " 4 "
Coal	4 inches.	4 "	48 " 8 "
Fire Clay, sandy		6 feet 4 "	55 "
Sandstone, gray		20 "	75 "
Sandy Shale		4 " 11 inches.	79 " 11 inches.
Coal	42 inches.	3 " 6 "	83 " 5 "

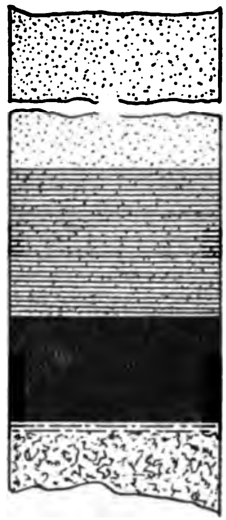


FIGURE 7. Section of Well at Scammon.

In F and G the Upper is reached at 16 feet and 13 feet respectively from the surface. The coal in this stratum averages 9 inches, and is poor in quality, carrying much pyrite or "sulphur" and "black jack." The floor and roof are good. The Lower stratum, reached at a depth of 82 feet 10 inches and 79 feet 11 inches, respectively, is found to vary considerably in thickness, in G maintaining its usual thickness of 42 inches, while in F it has shrunk to 13 inches. This is simply a local thinning out, a phenomenon which is not of infrequent occurrence. The roof in the above mentioned mine is composed principally of sandstone and arenaceous shales, forming a brittle, unreliable covering to the coal. Fire clay and occasionally a little "black jack" comprise the floor of the mine. The coal is a very good quality, but is somewhat pyritiferous.

As will be seen in examining F a new coal stratum makes its appearance still lower than the one mentioned in D. It is not found in G.

WEIR CITY AND VICINITY.

A section on the Lewis farm about 300 yards northwest of No. 8 shaft gives a fair record.

H.—*Record of a Well near Weir City.*

MATERIAL.	Thickness of Coal.	Thickness of Strata.	Depth to Bottom of Strata.
Soil and Clay		10 feet.	10 feet.
Shale		6 "	16 "
Sandstone		1 "	17 "
Blue Shale		3 " 6 inches.	20 " 6 inches.
Coal	5 inches.	5 "	20 " 11 "
Fire Clay		9 " 1 "	30 "
Shale, gray		6 "	36 "
Sandstone, gray		11 "	47 "
Sandy Shale		10 " 1 inches.	57 " 1 inch.
Coal	39 inches	3 " 3 "	60 " 4 "

The Weir-Pittsburg has dropped out at this place. The Intermediate coal stratum, mentioned in connection with the record D, still occurs at approximately the same hight above the Lower, having a thickness of 5 inches. At 57 feet 1 inch the Lower stratum is mined. The coal is of a good quality, although considerable "sulphur" and "black jack" are found in spots. The roof is made up of arenaceous shale, the same as that noted in G, with a floor made up of fire clay. "Horsebacks" are quite numerous.

On the Kepple farm, near shaft No. 5, a drill hole record shows the strata assuming the following order:

I.—*Record of a Drill Hole near Weir City.*

MATERIAL.	Thickness of Coal.	Thickness of Strata.	Depth to Bottom of Strata.
Clay and Sandstone		13 feet.	13 feet.
Shale, hard and soft		3 " 6 inches.	16 " 6 inches.
Blue Sandy Shale, hard		7 " 6 "	24 "
Blue Shale		3 "	27 "
Blue Black Shale, soft		3 "	30 "
Coal	6 inches.	6 inches.	30 " 6 inches.
Fire Clay		3 feet.	33 " 6 "
Fire Clay, sandy		4 "	37 " 6 "
Sand and Shale		10 "	47 " 6 "
Fire Clay		2 "	49 " 6 "
Sandy Shale		6 "	55 " 6 "
Coal	48 inches.	4 "	59 " 6 "

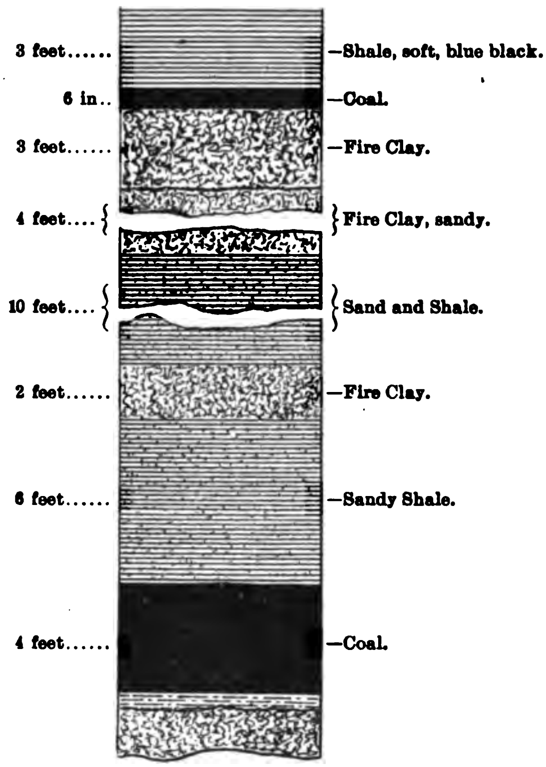


FIGURE 8. Section of Drill Hole on the Kepple Farm near Weir City.

The Intermediate 6 inch stratum is still persistent. The Lower is found here at a depth of 59 feet 6 inches, with a thickness of 4 feet. The coal is good, although containing some "sulphur" and "black jack." The roof is breaking down into a soft bituminous shale. The floor is of fire clay and "black jack" and is fairly good. "Horsebacks" are numerous.

One and a half miles north of Weir City on the Daisy farm, a prospect hole was sunk within about 250 yards of the Daisy shaft. From the record of this hole the following sequence of strata was noted :

J.—Record of Prospect Hole on the Daisy Farm.

Material.	Thickness of Coal.	Thickness of Strata.	Depth to Bottom of Strata.
Soil and Clay	....	8 feet 6 inches.	8 feet 6 inches.
Sandstone	....	10 "	18 " 6 "
Shale, gray and soft	....	6 " 6 inches.	25 "
Coal	2 inches.	2 "	25 " 2 "
Clay, black	....	2 " 2 "	27 " 4 "
Shale, bluish gray	....	6 " 6 "	33 " 10 "
Ironstone	....	4 "	34 " 2 "
Blue Black Shale	....	3 "	37 " 2 "
Coal	4 inches.	4 inches.	37 " 6 "
Fire Clay	....	1 " 8 "	39 " 2 "
Gray Sand	....	1 " 10 "	41 "
Fire Clay	....	10 "	51 "
Dark Sand	....	10 " 6 inches.	61 " 6 "
Shale, soft	....	3 "	64 " 6 "
Gray Sandy Shale	....	5 " 10 inches.	70 " 4 "
Sandstone, blue	....	3 " 8 "	74 "
Coal	42 inches.	3 " 6 "	77 " 6 "

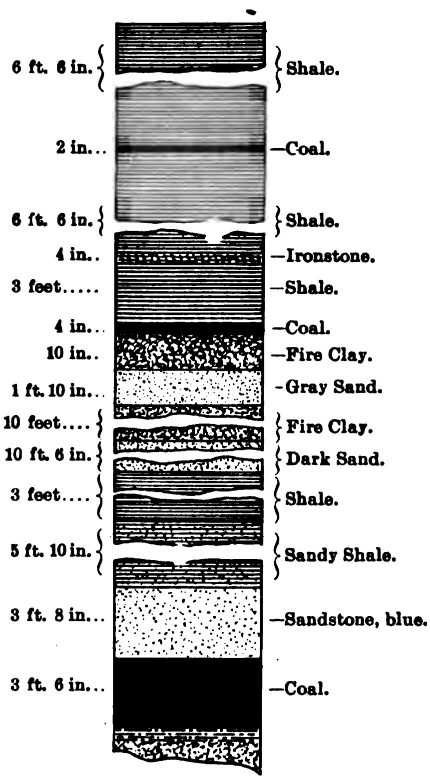


FIGURE 9. Section of Drill Hole on Daisy Farm near Weir City.

The Weir-Pittsburg Upper is here represented by a 2-inch stratum of coal and "black jack" or bituminous shale. The roof is soft shale and is weak. The floor is bituminous clay. The Intermediate stratum occurs 36 feet above the Lower and has a thickness of only a few inches at this point. The roof is bituminous and blue shale; the floor is fire clay. The Lower stratum, reached at a depth of 74 feet has a blue sandstone roof which is bituminous. The coal if of good quality and of average thickness, 3 feet 6 inches. The floor is fire clay; "horsebacks" are quite numerous; "sulphur" and "black jack" are quite abundant, with the "sulphur" occurring in balls or in rounded masses in the seams of the coal. A 4-inch stratum of ironstone, or "bastard rock," as called by the miners, is found 32 feet from the surface. This form of rock occurs quite frequently throughout the Cherokee shales, especially to the north. The bituminous, carbonaceous, and arenaceous shales are still found to merge back and fourth in rapid succession.

On Mr. Scranton's estate, in the southern part of Weir City, about a half mile from the main street, a shaft has been in operation for several years. The lower stratum of coal is worked here at a depth of 30 odd feet. The Upper stratum was passed through not as coal but bearing close resemblance to soft charcoal, a soft, black, bituminous, and carbonaceous earth. The 6 inch stratum before mentioned as lying between the Upper and the Lower is found at this point. To the east of this shaft about a half mile the Lower stratum comes to the surface in a ravine.

Starting from a point a few rods south of this shaft and passing around to the east and north of Weir from one-half mile to a mile and a half of the city strip pits are numerous. These strippings are located on or near the outcropping of the Lower stratum, the Upper cropping out further to the west. The average thickness of material removed in these strippings is 10 feet, although varying from 6 to 16 feet. The coal thus obtained is of a fairly good quality but, on account of its nearness to the surface, has been so thoroughly saturated by surface

waters that it is badly slacked and therefore rendered soft and difficult to handle. For several years it has been mined quite extensively by stripping in the northern part of the city to supply the smelters located near by, but recently less has been stripped than formerly. The covering of the coal is, as a rule, light blue shale, often merging into arenaceous shales and sandstone. The floor is fire clay; "horsebacks" are quite numerous and troublesome.

About a mile and a half northeast of Scammon considerable mining by stripping has been done in times past. Coal is still removed at this point by Mr. Clemens, and there is demand for it. The coal in this neighborhood is in better condition than that stripped further east. The reason for this is that it is farther from the outcroppings and is generally at a greater depth and is therefore less affected by weathering, but it is also more expensive to work. "Horsebacks" occur quite frequently in these strippings.

CHICOPEE.

Three prospect drill holes in the vicinity of Chicopee will serve to show the association of strata at this point. The record of hole No. 1, located on section 27, township 30, range 24, reads as follows:

K.—*Record of a Prospect Well near Chicopee.*

MATERIAL.	Thickness of Coal.	Thickness of Strata.	Depth to Bottom of Strata.
Soil		13 feet.	13 feet.
Gray Shale		4 " 6 inches.	17 " 6 inches.
Dark Shale		4 " 6 "	22 "
Gray Shale		10 "	22 " 10 "
Coal	10½ inches.	10½ "	23 " 8½ "
Gray Shale		7 feet.	30 " 8½ "
Black Shale, hard		5 " 1 inch.	35 " 9½ "
Coal	7 inches.	7 "	36 " 4½ "
Gray Shale		10 "	37 " 2½ "
Black Shale		5 feet 1 "	42 " 3½ "
Coal	6½ inches.	6½ "	42 " 10 "
Gray Shale, hard		22 "	64 " 10 "
Gray Sandstone, hard		9 " 7 inches.	74 " 5 "
Coal	32 inches.	2 " 8 "	77 " 1 "
Black Shale		1 "	78 " 1 "
Gray Shale, soft		6 " 4 inches.	84 " 5 "

Total depth of well, 95 feet 7 inches.

Hole No. 2, on section 27, township 30, range 24, gives the following sequence of strata:

L.—*Record of a Prospect Well near Chicopee.*

MATERIAL.	Thickness of Coal.	Thickness of Strata.	Depth to Bottom of Strata.
Clay and Gumbo		17 feet 3 inches.	17 feet 3 inches.
Black Shale, hard		5 " 5 "	22 " 8 "
Coal	**32 inches.**	**2 " 8 "**	**25 " 4 "**
Gray argillaceous Shale		6 "	31 " 4 "
Limestone, blue, fossiliferous		8 inches.	32 "
Gray argillaceous Shale		8 " 6 "	40 " 6 "
Black Shale		3 " 8 "	44 " 2 "
Coal	**14 inches.**	**1 " 2 "**	**45 " 4 "**
Gray argillaceous Shale		4 "	49 " 4 "
Gray Shale		22 " 2 inches.	71 " 6 "
Black Shale		6 "	77 " 6 "
Coal	**6 inches.**	**6 inches.**	**78 "**
Gray arenaceous Shale		12 " 6 "	90 " 6 "
" " "		2 "	92 " 6 "
" " "		6 "	98 " 6 "
Coal	**39 inches.**	**3 " 3 inches.**	**101 " 9 "**
Black Shale		1 " 1 "	102 " 10 "

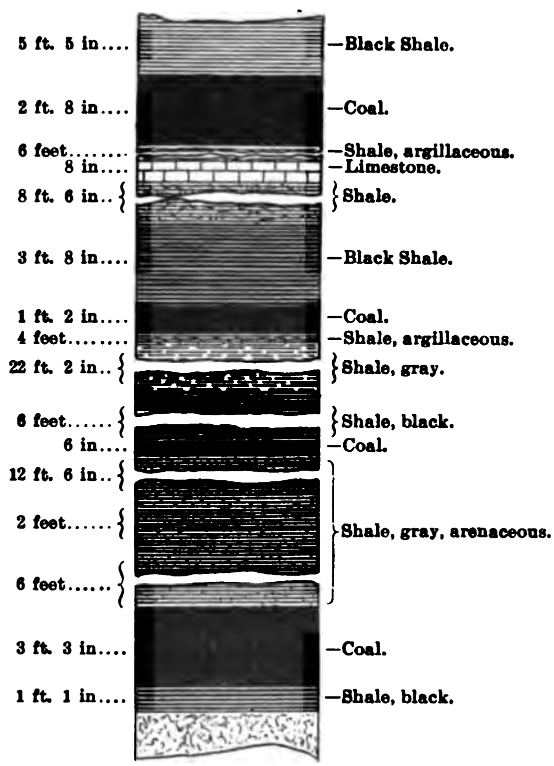


FIGURE 10. Section of Drill Hole near Chicopee.

Hole No. 3, located on section 27, township 30, range 24, although a trifle deeper than either 1 or 2 — K or L — shows the same association of strata at this locality. The record is as follows:

M.—*Record of a Prospect Well near Chicopee.*

MATERIAL.	Thickness of Coal.	Thickness of Strata.	Depth to Bottom of Strata.
Clay and Gumbo	....	12 feet 8 inches.	12 feet 8 inches.
Black Clay	....	2 "	14 " 8 "
Coal	**28 inches.**	2 " 4 inches.	17 "
Argillaceous Shale, gray	....	11 "	28 "
Blue Limestone	....	6 inches.	28 " 6 inches.
Argillaceous Shale, gray	....	4 " 6 "	33 "
Dark Shale	....	10 "	33 " 10 "
Gray Limestone	....	1 " 2 "	35 "
Dark Shale	....	4 "	35 " 4 "
Coal	**9 inches.**	9 "	36 " 1 "
Argillaceous Shale, gray	....	5 feet 7 "	41 " 8 "
Gray Shale	....	19 " 9 "	61 " 5 "
Black Shale	....	2 "	63 " 5 "
Blue Limestone	....	4 inches.	63 " 9 "
Black Shale	....	4 " 4 "	68 " 1 "
Coal	**5 inches.**	5 "	68 " 6 "
Gray Shale	....	9 "	77 " 6 "
Gray Sandstone	....	1 " 6 inches.	79 "
Shale, hard	....	1 " 6 "	80 " 6 "
Blue Limestone	....	7 "	81 " 1 "
Gray Shale, hard	....	10 "	91 " 1 "
Gray Sandstone	....	3 " 4 inches.	94 " 5 "
Gray Shale, hard	....	1 " 8 "	96 " 1 "
Coal	**25⅛ inches.**	2 " 1⅛ "	98 " 2⅛ "
Dark argillaceous Shale	....	1 "	99 " 2⅛ "

The Upper stratum is reached in K, L, and M at 21, 22, and 14 feet, respectively. The roof of this coal is argillaceous and bituminous shale, in some places weak, but as a general rule making a fairly good supporting roof. The floor material is similar to that of the roof, being argillaceous shale.

The Intermediate stratum increases a trifle in thickness as it passes to the north, having here an average thickness of 7 inches. The bituminous shale here makes a very good covering and is quite persistent. The floor is a good quality of hard, gray shale and is tolerably level, making a good working floor.

The Lower stratum is reached at a depth of 83 feet 7 inches, 93 feet 6 inches, and 96 feet 1 inch, in K, L, and M, respectively. The roof merges from hard blue shale in M to arenaceous shale in L, then to hard sandstone in K. The floor consists of a very bituminous hard shale, yet in M an argillaceous shale is met with, making a poor working floor.

The large amount of bituminous (black) shales and clays found in these drill hole records, as well as the arenaceous shales and sandstone, are very characteristic of these shale beds as noted farther south.

THE AREA NORTH OF PITTSBURG AND CHICOPEE.

A smaller number of records of wells and shafts have been obtained from the area lying north of Chicopee and Pittsburg than have already been given for the southern portion of the country, but from observations taken covering the greater part of the above mentioned district it is found that the coal strata continue to dip gradually deeper beneath the surface to the north and west at an angle which does not differ materially from that already observed farther south. The Weir-Pittsburg Lower outcrops in the vicinity of Pittsburg and has been stripped quite extensively on the south, west, and north of the city. At present it is taken from the clay pits at the clay factory at which place it is found at a depth of from 16 to 20 feet below the surface, being overlaid with arenaceous and argillaceous shales. The line of outcrop passes northeastward from Pittsburg to the state line—eight to ten miles from Pittsburg. The outcropping is seen only in the ravines, consequently on the higher ground to the north and west the coal is mined by shafting.

DETAILS OF STRATIGRAPHY IN THE MINES.

To give a more definite idea of the depth of the workable strata of coal, their thickness, and the character of the associated strata, the exact data will be given as obtained directly from the operators of the various mines. The mines from which the following data were obtained are located principally in Cherokee county.

1. The Western Coal Mining Company, Mine No. 3. Fleming. The mine is 100 feet deep. Thickness of coal is 3 feet 3 inches. The roof is blue shale, merging into sandy shale. Considerable gas is found here. The floor is generally fire clay, but quite frequently pyritiferous "black jack." The Lower coal stratum is mined.

2. The Western Coal Mining Company, Mine No. 2. Fleming. The mine is 100 feet deep. Coal is 3 feet 2 to 4 inches in thickness. The floor is level and composed of fire clay and pyritiferous "black jack," which makes mining difficult as the force of the charge in blasting is lost in the elastic "black jack." The roof is shale, sometimes sandy. The Lower coal stratum is mined here.

3. The Schaub Coal Company. The J. H. Durkee Coal Company, lessee, Mine No. 3. The mine is located on the southwest quarter of section 6, township 32, range 24. The mine is 50 feet deep and the coal is 3 feet 6 inches in thickness. Very little "black jack" is found associated with roof or floor. Little or no iron pyrite or "sulphur" occurs. The floor is level and smooth and composed of fire clay. The roof is blue shale and a trifle arenaceous in places. The Lower coal stratum is mined.

4. Hamilton and Grant Coal Company, Mine No. 3. Weir City. The mine is 30 feet deep. Coal is 3 feet 6 inches thick. "Horsebacks" are numerous and "black jack" is troublesome. The roof is composed of shale and sandy shale. The floor is "black jack" and fire clay. The Lower coal stratum is the one mined.

5. Kansas and Texas Coal Company, Mine No. 47. North of Weir three miles. The mine is 30 feet deep and the coal 3 feet 4 to 6 inches in thickness. The floor dips to the northwest, is quite smooth, and is composed principally of fire clay with a little "black jack" intermixed. Roof is shale—fairly good. Lower coal stratum is mined.

6. Kansas and Texas Coal Company, Mine No. 23. North of Weir three miles. The mine is 42 feet deep. Coal is 3 feet 6 to 8 inches in thickness. The floor is rather uneven and is composed of fire clay and "black jack." The roof is shale and sandy shale. The Lower stratum is mined.

7. Kansas and Texas Coal Company, Mine No. 18. North of Weir nearly three miles. The mine is 76 feet deep and the coal is 3 feet 6 inches in thickness. The roof is arenaceous shale and sandstone—poor. The floor is composed of shale and

"black jack," 3 to 4 inches in thickness, then fire clay—poor. "Horsebacks" are numerous. The Lower stratum is mined.

8. Hamilton and Braidwood, Mine No. 2. In the vicinity of Weir. The mine is 73 feet deep. Coal is 3 feet 3 to 6 inches thick. The roof is arenaceous shale and sandstone—poor. There are 6 inches of "black jack" under the coal, then fire clay. At this point the drill hole, 110 feet deep, shows two other coal strata—10 and 8 inches in thickness, respectively. The depths at which these two strata were reached were not known to the operator. The roof is arenaceous shale. "Horsebacks" are of frequent occurrence. The Lower stratum is worked.

9. The Central Coal and Coke Company, Mine No. 5. In the vicinity of Weir. Mine is 60 feet deep. Coal is 3 feet 6 inches thick. A strip of faulty coal, several rods wide, passes through this neighborhood trending northeast and southwest. "Horsebacks" are very numerous. The roof is arenaceous shale and shale. The floor is fire clay and "black jack." "Black jack" is not very troublesome. Lower stratum is worked.

10. Durkee Coal Company, Mine No. 1. Location: East half of the northeast quarter of section 33, township 31, range 24. The mine is 50 feet deep, and coal is 3 feet 8 inches in thickness, and dips very perceptibly to the northwest. The roof is shale and sandy shale. The floor is fire clay and "black jack," but there is very little of the latter. Lower stratum is mined.

11. John Bennett Coal Company, Mine No. 5. In the vicinity of Weir. Mine is 55 feet deep. Coal is 3 feet 6 inches in thickness. The roof is shale. The floor, composed of "black jack" and fire clay, dips to the northwest. "Horsebacks" are numerous. The stratum mined is the Lower.

12. Central Coal and Coke Company, Mine No. 8. West of Weir. The mine is 75 feet deep. The coal is 3 feet 4 to 6 inches thick. The floor is almost level, dipping to the west slightly, and is composed of fire clay and "black jack," with very little of the latter. The roof is shale, fairly good.

"Horsebacks" are of frequent occurrence. The stratum mined is the Lower.

13. Weir Brothers' Coal Company, Mine No. 2. Weir City. Mine is 96 feet deep. The coal is 3 feet 4 to 8 inches thick. The floor is fire clay and "black jack." The roof is shale and sandy shale. Some gas is found here. "Horsebacks" are met occasionally. The stratum worked is the Lower.

14. Central Coal and Coke Company, Mine No. 6. West of Weir. Mine is 72 feet deep. Coal is 3 feet 8 inches thick. Floor is fire clay and "black jack." Roof is blue shale. "Horsebacks" are numerous. Lower stratum is worked.

15. Davis Coal Company, Mine No. 3. The mine is located on the northeast quarter of section 19, township 31, range 24. Cherokee. Depth of mine is 150 feet. Two strata are found here. The first is reached at a depth of 40 feet where the coal is 2 feet thick; the second at a depth of 150 feet where the coal is 3 feet 3 to 6 inches thick. The floor is fire clay with a thin stratum of "black jack" next to the coal. "Horsebacks" are not numerous. The Lower stratum is mined.

16. Norton's Works, Mine No. 2. Durkee Coal Company, lessee, Mine No. 3. Scammon. The mine is 67 feet deep, and the coal is 4 feet in thickness. Floor strata as shown in "sump" are as follows: "Black jack" 2 to 3 inches in thickness; blue shale 18 to 20 inches; coal 2 to 3 inches; and fire clay 2 to 3 feet in thickness. The roof is arenaceous shale and sandstone, fossiliferous. The floor is rough and wavy and dips to the northwest. "Horsebacks" are numerous. The stratum mined is the Lower.

17. The Durkee Coal Company, Mine No. 4. Location is on the northeast half of section 16, township 31, range 24. The mine is 60 feet deep. Coal is 3 feet 6 inches to 4 feet thick. The roof is blue shale. The floor is "black jack," shale, and fire clay, similar to that found in No. 16. "Horsebacks" are quite numerous. The Lower stratum is worked.

18. Southwestern Coal and Improvement Company, Mine No. 6. Mineral City. The mine is 125 feet deep. The coal is 3 feet 8 to 10 inches in thickness. "Horsebacks" are very

troublesome. The roof is blue shale and is fairly good. The floor is "black jack" and pyritiferous fire clay. The coal carries considerable pyrite in the nature of fine seams and bands. The floor is wavy and dips to the northwest. Gas is found here. The Mineral City Lower is mined here.

19. The McCune Coal Company. McCune. This company's mine is 400 feet deep. There are six strata of coal. One is 6 inches in thickness; three are 1 foot each in thickness; one is 2 feet; and one is 18 inches. Both the 18 inch and the 2 foot strata have been worked. The 24 inch strata is probably the Weir-Pittsburg Upper. The roof is shale and sandstone. The floor is fire clay and "black jack."

20. Columbus Coal Company, Mine No. 4. This mine is located at the southeast corner of the northwest quarter of section —, township 32, range 24, and is 25 feet deep. The coal is 4 feet thick. The roof is blue shale and sandy shale. The floor is fire clay and "black jack." "Horsebacks" occur here. The stratum worked is the Lower.

INCLINATION OF COAL BEDS.

It is desirable to determine the inclination of the coal beds. The practical question for the miner being the distance below the surface at which the coal is found the inclination of the coal beds with reference to the surface rather than with reference to a level will be sought after. But as the whole of the coal mining area in Cherokee and Crawford counties is almost level the figures obtained will not differ materially from figures obtained showing the dip referred to the horizontal.

The Weir-Pittsburg Lower may be traced from its outcropping three-fourths of a mile east of Weir westward to the limit of mining operations at Mineral City, by noticing its position in the records of the strip-pits, shafts, and drill holes located between these two points. The Lower occurs here as follows:

1. In the strip-pits east of Weir at a depth of from 10 to 16 feet.
2. At Mr. Scranton's mine in the southeastern part of Weir at a depth of 30 odd feet.
3. In the Daisy shaft at a depth of 75 feet.

4. In prospect hole No. 2 as seen in record G at a depth of 79 feet.

5. At Cherokee at a depth of 150 feet.

6. In prospect hole, record A, five miles north of Mineral City, at 229 feet 6 inches.

This makes an average westward dip below the surface of 20 feet to the mile.

The Weir-Pittsburg Lower may be traced to the north from its outcropping near Columbus, but as the exact location of the outcrop is uncertain, due to the covering of soil, it would probably be best to use the locality where the exact depth of the stratum is known as the initial point in the correlation on the south.

1. A shaft at Stippville, a few miles north of Columbus, reached the Lower stratum at a depth of 25 feet.

2. On the Perry farm two and a half miles south of Scammon, in prospect hole No. 2, record D, it was found at a depth of 24 feet 8 inches.

3. On the Scammon farm, near Scammon, in hole No. 2, record G, the Weir-Pittsburg Lower was reached at a depth of 79 feet 11 inches.

4. Still farther north at the Daisy shaft, on the Daisy farm, it was met with at a depth of 75 feet.

5. At the M. K. & T. mine No. 18, a few miles north of Weir, it is reached at a depth of 75 feet.

6. At Fleming the same stratum is worked at a depth of 100 feet.

From the above it will be seen that the dip to the north is on the average 4 feet to the mile below the surface.

The Weir-Pittsburg Upper stratum may be traced as follows:

1. It is first noted in records F and G at 16 and 13 feet, respectively.

2. In the Daisy shaft the Upper occurs at a depth of 20 odd feet.

3. At Fleming this stratum is reached at 18 or 20 feet.

We thus see that this coal stratum is dipping below the surface on an average of 3 feet to the mile, in passing northward.

Passing westward from Weir to Mineral City and vicinity the

following points may be noted at which the Upper stratum can be found:

1. The "blossom" of the Upper appears on the Scranton farm one-half mile south of Weir at a few feet from the surface.

2. On the Daisy farm, one and one-half miles north of Weir (see record J), the Upper is reached at a depth of 24 feet from the surface.

3. Near Scammon, in hole No. 2, record F, it is reached at a depth of 16 feet.

4. At Cherokee it was reached at a depth of 40 feet.

5. North of Mineral City, see records A and B, it was reached at 96 feet 7 inches and 122 feet 2 inches, respectively.

This gives for the Upper an average westward dip beneath the surface of 12 feet to the mile.

This difference in westward inclination of the two main coal beds is somewhat surprising and at the same time interesting. It implies that throughout this area there was a more rapid accumulation of shale forming material to the west during the interval between the production of the two coal beds. This excessive westward thickening averages 8 feet to the mile, the difference between the dip of the two coal beds. The general westward inclination of the Cherokee shales as a whole along the south line of the state, as shown in Plates I and II, is about 20 feet to the mile. The westward inclination of the Lower or principal coal bed is therefore about the same as that of the Cherokee shales, while the position of the Upper coal bed is such that it is inclined to the general bedding planes of the Cherokee shales.

The dip of the Cherokee shales to the north and west, in Cherokee county, is therefore quite marked, which dip soon carries them below the higher geological formations to the north and west, and to such a depth that in a comparatively short distance beyond the upper line of outcrop the accompanying coal strata become, for the present, unworkable.

The Intermediate coal stratum is as persistent in the constancy of its thickness and extent of occurrence as well as in its dip as are the Upper and Lower.

Arcadia Area.

At Arcadia three strata are found from which considerable coal is removed. The upper stratum comes within a few feet of the summits of Bunker Hill and Coal Mound, at which places it is mined. It resembles the Fort Scott "red" and is much used as a domestic fuel. The second stratum is stripped just east of town, and is also drifted for on the creek bank south of Arcadia. At Coalvale, about four miles south of Arcadia, a third stratum is shafted for in the creek valley. These coal strata average probably 20 inches in thickness and produce large quantities of good coal which is put on the market in competition with Weir-Pittsburg coals to the south. These strata belong to the Cherokee Shales, but are higher than those to the south. Plate XXXI shows the association of strata found here.

Fort Scott Area.

Near the top of the Cherokee shales in the vicinity of Fort Scott coal has been mined for over thirty years. Here there are two beds of coal, one from 6 to 10 feet below the lower Oswego limestone, and the other 60 feet or more still further below. The former is mined in many places around Fort Scott, while the latter is mined to a lesser extent near the state line along the Drywood and along the Marmaton.

Coal mining was first begun in the Fort Scott vicinity about the close of the war, in 1865. The upper bed of coal outcropped in a thousand places along the banks of the ravines and larger tributaries of the Marmaton. Here exposed to the weathering agents the iron sulphide within it became oxidized, producing iron rust which gave the coal a rusty appearance from which the name "red coal" was derived. Being so close to the overlying Oswego limestone the escarpments and steep bluffs produced on account of the protective action of the limestone made it possible for the coal to be oxidized completely along the surface and to be practically unaffected only a few feet back in the bank. The contrast between this condition and the conditions in the vicinity of Weir City and Pittsburg, where there is no protective limestone overlying, is very great. In the latter place such a weathering and such a production of

"red" coal extends many times as far back from the line of outcropping while this outcropping line is concealed almost entirely by the overlying soil so plentifully produced by the decomposition of the shales.

When the Kansas City, Fort Scott & Gulf railroad, now the Kansas City, Fort Scott & Memphis railroad, entered Fort Scott in 1869 a strong demand was created for coal which was principally supplied by mining the Fort Scott "red." The road soon ran a switch into the mining territory five or six miles southeast of Fort Scott so that the coal could be loaded directly on the cars. Previous to this improvement it had been teamed to the stations of Fort Scott and Godfrey and loaded onto the cars from wagons. Later, after the road had reached the southern state line, and after the coal mines in Cherokee and Crawford counties were opened, the railroad found it to their advantage to obtain their supply of coal from the southern mines where the coal is thicker and consequently cheaper.

Since that date the principal mining of the Fort Scott coals has been confined to supplying the local demand. Occurring in so many places immediately at the surface where stripping can be done at so low an expense and where drifts can be carried back into the bank a short distance without the use of machinery it offers an excellent opportunity for the small miner to work at odd times and during the winter and to devote the remainder of his time to other employment. Many thousands of bushels are mined annually in this way and carted into Fort Scott for the retail market. The "rusty" coal is particularly desirable for use in the forges of blacksmiths and also for other fires where the presence of a small amount of sulphur is especially objectionable. The output of Bourbon county is confined principally to these two beds from the Cherokee shales, the upper one of which furnishes the "rusty" coal. Still, a small amount of coal is mined in the northern part of Bourbon county from beds which occupy a higher position, as will be explained under the Pleasanton shales.

In 1897 Bourbon county produced 28,483 tons of coal, which equals .86 per cent. of the total state production.

Leavenworth Area.[3]

North from Fort Scott no coal has been mined from the Cherokee shales until the vicinity of Leavenworth is reached. Here the Leavenworth coal is obtained from the upper part of the Cherokee shales. The coal at this place is about 2 feet thick, averaging for the whole mine run possibly a little less. Twenty-five feet below the coal which is being worked lies another bed of about the same thickness and quality although it has not yet been mined, while still further below is a third coal bed also about 2 feet in thickness. The Leavenworth mining area lies just to the southeast of the Oread escarpment, so that in order to reach the coal the shaft must pass through the lower part of the Lawrence shales and all intervening formations, which here are not as thick as they are in the southern part of the state by some 200 or 300 feet.

This same coal horizon outcrops further east, in Missouri, from which coal has been mined for more than forty years. It was the knowledge of this outcropping that led that veteran geologist, Maj. F. Hawn, to predict so emphatically the existence of coal under Leavenworth and to estimate its depth so accurately. Fortunately for him and all concerned his prediction came true, although dozens of oil and gas wells in southern Kansas, starting from about the same geologic horizon, just east of the Oread escarpment, have passed entirely through the Cherokee shales without finding nearly so much coal as exists at Leavenworth. Had Major Hawn been familiar with many of the facts recently brought to light in drilling for oil and gas in southern Kansas probably his faith in the existence of the Leavenworth coal would have been less strong and most likely the Leavenworth mines never would have been developed.

History of Development of the Leavenworth Area.

In 1859, after much persistent effort, Major Hawn organized the Leavenworth Coal Mining Company. The next year twenty acres of land on the government reservation were leased and a prospect hole was commenced with a rude drill operated by a

3. Jameson, E.: Coal Resources of Leavenworth, Kansas, Leavenworth, 1890.

spring pole. The civil war, lack of money, and want of confidence in Major Hawn's convictions led the company to abandon the enterprise and to transfer all their rights to Major Hawn who continued the prospecting intermittently as he could secure means to push it.

A 2 foot bed of coal was reached in 1865. The city now granted to Major Hawn the right to mine under the streets and alleys of Leavenworth. A new company was then organized and the right to mine under the military reservation was granted by the Post Commander and confirmed by the Secretary of War. On July 20, 1868, Congress confirmed this grant and sold the company a tract of twenty acres from the reservation. In January 1869, Major Hawn transferred back to the Leavenworth Coal Mining Company all his rights in the mines and lands.

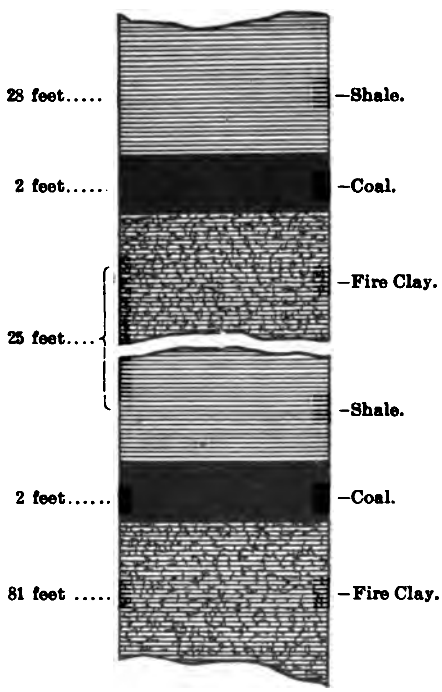


FIGURE 11. Section of the Lansing Coal Shaft.

The shaft reached the bed of coal at 713 feet in 1870. For two years the mine was operated at a loss. It had cost $200,000, the stock represented $300,000 face value, but was worth only fifteen cents on the dollar in the market. Through the influence of Doctor Sinks, a gentleman much interested in the mining operations, Hon. Lucien Scott, of the First National Bank, in 1872 purchased a large interest in the mine and in the same year the company employed as mine superintendent a practical mining engineer, Mr. John E. Carr, a man of wide experience in managing mines in England and in different parts of America. Under his supervision the mine was retimbered, the ventilation improved, and the capacity greatly enlarged. In 1880 a new shaft was sunk, and in 1882 the size of the old shaft was increased, and the most improved machinery introduced in the mine and buildings. A system of cable roads was introduced in 1885, supplanting the mule cars commonly employed in coal mines. A hole has since been drilled below the shaft to a total depth of 1130 feet and shows four workable beds of coal, aggregating 8 feet.

In 1879 the Legislature authorized the officers of the State Penitentiary to sink a shaft at Lansing and appropriated $25,000 for that purpose. On November 20, 1879, under the direction of Mr. Oscar F. Lamm, the shaft was begun, and on January 15, 1881, coal was reached at 713 feet.

In 1885, Mr. John Braidwood, State Inspector of Coal Mines, resigned his position and assisted in organizing the Riverside Coal Company. That fall the city voted $10,000 in bonds in aid of the enterprise, as authorized by the Legislature at its previous session. The shaft was begun on January 17, 1886, and coal reached on September 17, of the same year. The shaft was sunk and coal hoisting begun at a cost of less than $50,000. In 1888 this company began freighting coal down the Missouri river to Kansas City in barges, but the difficulties of river navigation were so great that this was soon abandoned.

In March, 1889, the shaft of the Home Coal Mining Company reached coal at a depth of 710 feet and mining was actively begun. The shaft was carried 30 feet below the first bed and at

25 feet a second bed of 22 inch coal was found, the same as has since been shown by the drill at other places.

Several other attempts at coal mining were made about 1888 and 1889. The Brighton Coal Company's shaft was the next one completed and reached coal at a depth of 850 feet about the close of 1889. This shaft was operated for one season, after which work was suspended and has not been resumed. A prospect hole was drilled in 1889 at Tonganoxie and coal found at a depth of 850 feet, but no development has yet been made.

The Home Coal Mining Company and the Riverside Coal Company were consolidated on August 1, 1894, under the name of the Home-Riverside Mining Company. The two shafts, about a mile apart, were connected by a tunnel, making them virtually one large mine.

The production and number of men employed by the Leavenworth mines during 1897 is as follows:

Leavenworth Company	112,261 tons,	301 men.
Home-Riverside Company	190,000 "	435 "
Penitentiary mine	64,880 "	336 "
Total of Leavenworth county	367,141 tons,	1,072 men.

Coal Production from the Cherokee Shales.

From the foregoing discussion it will be seen that the Cherokee shales are a great coal producing formation and that at present they produce nearly all the coal mined in the state. By reference to Table III, page 193, it will be seen that for 1897 they produced 93.32 per cent. of the total state output, and that for preceding years they produced a proportion which gradually decreases backwards. With the current low price of coal and the consequent necessity of operating mines which can produce coal at the least possible cost the tendency will be for the per cent. of output from the Cherokee shales to increase. Should the time come when the price of coal will permit the operation of the many lesser mines in the upper horizons then we shall have a relative decrease in the production from the Cherokee shales.

FUTURE OF COAL PRODUCTION FROM THE CHEROKEE SHALES.

No question in connection with the coal fields of Kansas is of more vital importance than that of the future production from the Cherokee shales. At the rate at which coal is mined in Cherokee and Crawford counties it can be readily seen that within a few generations the coal now known to be available near the surface in those two counties will have been removed. Nothing but the most careful and detailed prospecting with the drill will determine in advance the extent of these heavy coal beds in Cherokee and Crawford counties. It is well known, as has already been pointed out, that there are many other lesser beds covering wide areas, the extent of which cannot be given at present, even approximately, on account of the little development that has been made.

The great question for the future is with reference to the existence of coal beds farther to the west, coal overlaid by the Oswego limestone and succeeding formations. There is no reason known to the geologist why one may not confidently expect large quantities of coal in such positions. The mere fact that the overlying strata have not been worn away by erosion has no bearing whatever on the subject. The whole question depends entirely upon the physical conditions which existed during the formation of the Cherokee shale beds. If these conditions were favorable for the extensive growth of the coal plants and their preservation then large accumulations of coal must exist farther to the west. If, on the other hand, the conditions were not favorable for such growth and preservation then such coal need not be expected. The hundreds of deep wells in different parts of the state show conclusively that the Cherokee shales wherever penetrated contain large quantities of organic matter. Yet it must be confessed that the failure to discover heavy beds of coal throughout the oil and gas area is somewhat discouraging for one who hopes for the existence of such coal beds. The coal at Leavenworth and at Cherryvale and at a few other points where wells have shown its existence proves that there is a greater amount of coal existing at greater depths.

These various well records, as shown in detail in Part I of this volume, show that the Cherokee shales do extend away to the westward for an indefinite distance. If there are three distinct coal beds at Leavenworth each of which is two feet in thickness, and if there is one at Cherryvale 27 inches in thickness, no one can say why we should not expect similar or possibly even greater deposits to be found elsewhere in the deeply buried Cherokee shales.

But from the well known conditions under which coal is formed and from our knowledge of the position and trend of the coastal borders during early Coal Measure times in general it must be true that the farther west one goes the less prospect one has of finding workable coal deposits. This fact is illustrated on the last sheet of the coal map, Plate VIII, where the intensity of shading represents in a measure the degree of probability of finding workable coal beds in the Cherokee shales throughout their westward extension.

LABETTE SHALES.

The Labette shales, occupying the position between the Oswego limestones below and the Pawnee limestone above, as far as is now known carry but little coal. At a few points to the southwest of Prescott a thin bed of coal from 6 to 8 inches in thickness has been known and years ago was worked a little by the strip pit method. Aside from this no coal, more than the merest streak, is thus far known within the Labette shales.

PLEASANTON SHALES.

The Pleasanton shales, occupying the position between the Pawnee limestone and the Erie limestones, carry a large amount of coal, particularly in the lower parts. In northern Bourbon county and in many places in Linn county coal has been mined extensively both by the strip pit method and by shafting. In southeastern Linn county and northeastern Bourbon county the strip pit method is the most common. Here in the vicinity of Hammond and Fulton and Prescott and Miami, along the Memphis railroad, and at other points farther west are scores

of strip pits which are worked during the winter season and abandoned during the summer.

The coal varies from 16 to 30 inches and in some places is reported to be as much as 3 feet thick. It is of good quality, is easily obtained, and is used very extensively for local consumption throughout the whole area.

In the vicinity of Pleasanton, Boicourt, and La Cygne, coal mining by shafting has been prosecuted to a great extent. Here the coal is found lying close above the Pawnee limestone at a depth from the surface of from 60 to 100 feet, dependent upon the location. The coal in the shafts varies from 30 to 36 inches and is very nearly as good in quality as the coal from Cherokee and Crawford counties (see table of chemical analyses and of physical properties). The mines in the vicinity of La Cygne likewise obtain coal from the lower part of the Pleasanton shales which in quality is about the same as the coal found at Pleasanton and Boicourt.

West from Pleasanton, near Mound City, coal is mined at different places by stripping or by drifting, the coal here being a layer about a hundred feet vertically above the heavy coal obtained from the shafts farther east.

Coal mining was begun in the Pleasanton shales early in Kansas history. The coal was found near the surface and was easily mined by stripping, and therefore was obtained in sufficient quantities to supply the limited trade of those early days. The more extensive mining by shafting was begun later.

LAWRENCE SHALES.

As the Lane shales, first above the Iola limestone, do not produce coal the Lawrence shales form the first coal bearing horizon above the Pleasanton shales. This great shale bed, extending entirely across the state from north to south with a maximum thickness of 600 feet or more along the southern line of the state, produces coal in many localities.

Coal has been found in at least two distinct horizons within the Lawrence shales, the lower one in the vicinity of Lawrence being about 150 feet below the Oread limestones, and the upper

one at Atchison and also in the southwest corner of Franklin county around Pomona and Ransomville being from 30 to 50 feet below the Oread limestones. The coal of the upper horizon is not continuous from Atchison to Ransomville but is situated at about the same place relatively in the two localities.

The lower coal bed was formerly mined in many places in Douglas county. South of the Wakarusa over a territory from five to eight miles southeast and south of Lawrence many farmers from ten to twenty years ago opened mines and supplied themselves with fuel from the 16 inch bed of coal found almost everywhere in that part of the county. Generally the coal was mined by stripping where it came near the surface on the borders of the hills. Not infrequently however was shafting resorted to, the primitive appliances of the horse hoister being employed rather than the modern improved machinery. For the past decade these mines have been almost entirely abandoned on account of the low price of coal shipped in by rail from the larger mines. Mr. Bowman, of Sibley, continued mining until about 1893 when he in common with the others abandoned the enterprise.

In Franklin county coal from the Lawrence shales is still mined to a considerable extent throughout the whole year. A mine at Ransomville with a horse hoister is conducted continuously and partially supplies fuel for the Santa Fe trains running between Ottawa and Burlington. Other mines in this vicinity have been operated more extensively than they are at present. Along the Missouri Pacific line near Pomona and at a few other points in the same locality coal is yet mined. Likewise in many places through the western half of Franklin county the same coal bed is mined by the strip pit process. This coal lies from 30 to 40 feet below the Oread limestones and therefore outcrops on the face of the prominent escarpment produced by the Oread limestones and the Lawrence shales. As this escarpment is greatly corrugated by the upper ramifications of the numberless tributaries of the Osage river, many miles of outcropping of the coal are produced in the township. In driving

over the country one is greatly impressed by the large amount of debris left by the miner on the hillsides, in places being the product of the strip pits and elsewhere that produced by drifting into the hillsides. The coal here approaches about 16 inches but varies considerable, so that in places it is from 6 to 10 inches thicker and elsewhere a like amount thinner.

The Atchison mines were opened in the summer of 1893, the first discovery being along the walls of a narrow ravine leading to the Missouri river about two miles south of the city of Atchison. It seems that a colored man by the name of O'Connell was the first to engage in mining here. He began drifting on the coal bed and continued until he had obtained a few wagon loads which he hauled to Atchison. A few months later Donald Brothers, of Atchison, began operating a drift mine at the point of discovery and have continued the same until the present time. In 1897 two mines were operated, one by Donald Brothers and the other by Mr. Challis, and produced about 5000 tons of coal. The coal here is heavier, perhaps, than anywhere else thus far known in the Lawrence shales. It was 16 inches thick where first discovered and has a greater thickness in parts of the mine. The quality of the Atchison coal also is superior to that found elsewhere in the Lawrence shales.

In 1854, or thereabouts, coal was mined from the Lawrence shales in the vicinity of Leavenworth along Salt creek, and later, about 1861, along Little Stranger creek. This mining was continued for a few years only when it was entirely abandoned and has not been renewed since.

Southwest from Franklin county coal has been found in the Lawrence shales in many places separated from each other by irregular distances, a line of strip pits extending almost entirely to the south part of the state in Chautauqua county. This southern coal, however, is not of much value at present and as far as developed is inferior to the Franklin county coal and the Atchison county coal. What may be discovered in the future is wholly conjectural.

It is impossible to get any accurate statistics for the total production of coal from the Lawrence shales. The coal beds

being thin and the mining being conducted by individual enterprise at irregular times our reports of the State Inspector of Coal Mines in most cases have neglected them entirely. It is within reason to say, however, that the various mines within these shales have produced at least a hundred thousand tons to the present date. Their future capacity is principally dependent upon the current price of coal. So long as the heavier beds of coal in the state and adjoining territory supply coal for the large companies, that long the price will remain so low that the individual land owners throughout Douglas and Franklin and other counties cannot profitably mine the thin beds of coal on their land.

The amount of coal removed probably is but a small fraction of the total amount now lying buried within easy reach of the operator should the markets justify his seeking for it.

OSAGE SHALES.

Of all the shale beds contained within the Shawnee formation, the upper one, the Osage shales, is the only one that has produced coal. This shale bed is by far the most important coal producer known of any above the Cherokee shales. Here is one of the strange features of our Kansas coal. Situated more than 2000 feet vertically above the heavy coal beds of Cherokee and Crawford counties they have been their strongest rivals. Lying well within what previously has been called the Upper Coal Measures, corresponding to terranes generally considered barren in other parts of America, the Osage shales have large deposits of coal of a fairly good quality.

History of the Development of the Osage Coal.

Coal was first discovered in the Osage shales in the spring of 1869 by Mr. John F. Dodds, who began mining at the old point known as Carbon Hill, about two miles east of Carbondale, a station on the main line of the Santa Fe railway between Topeka and Emporia, in the northern part of Osage county. Here the coal was found on top of a prominent hill a short distance back from one of the upper tributaries of the Wakarusa.

The discovery was made while digging a well. The coal outcrops along the crests of the hills forming a long line from Carbon Hill southwest to beyond Osage City. In the autumn of 1869 mines were opened at Osage City by Godfrey and Price, of Hannibal, Missouri, who named their company the Carbon Coal and Mining Company of Missouri. A year or two later Mr. T. J. Peter bought their interests and continued operations under the same name excepting that the term Kansas was substituted instead of Missouri. It was as late as 1874 that the mines were first opened at Scranton, at which time Mr. O. H. Sheldon began operating strip pits and later began shafting. The same year a shaft was put down at the little town of Peterton, three or four miles north of Osage.

Mining did not begin at Burlingame until 1878 or 1879. The coal here is deeper and many thought that it did not exist. Finally it was discovered at from 90 to 100 feet below the surface, and mines were opened accordingly.

In 1880 the Santa Fe bought a half interest in the T. J. Peter Company which up to this time had been the principal company doing business in the whole vicinity. A year or two later it bought the remaining interest of the Peter Company and soon increased its purchases to about 30,000 acres of land in the Osage coal mining district. From that time to the present this company has been the principal coal mining company of the whole region, although many other companies have been in operation. The Santa Fe mines in Osage county practically supplied the whole Santa Fe system with coal for all points east of Colorado from the date of their purchase in 1880 until its mines were opened in Crawford county. In addition to this, as these mines were located on a great railway system, and as coal commanded a much higher price than at present, vast quantities of it were shipped into the general market. These were the most prosperous days for coal mining in Osage county. Recently the Santa Fe company has been disposing of its real estate in the county and now owns less than half the amount of land it at one time possessed.

When the Santa Fe Railway company leased its coal mining

property of the state to the newly organized Mount Carmel Company their Osage mining properties were included in the leases. At the present time no less than thirty-one companies are operating in this territory, but the Mount Carmel Company, as shown by the reports of the State Mine Inspector, does about 45.557 per cent. of the whole business.

Geologic Position of the Osage Coal.

The coal in the Osage shales lies about midway of the 200 feet of shales. In most localities it is capped by a thin limestone which seems to increase in thickness to the northward and which has recently been traced to the north line of the state. In Osage county the coal averages from 20 to 22 inches. The general inclination of the strata is to the west and northwest and therefore at any one place where coal can be mined by stripping shafting will discover the same coal a little ways to the west.

Burlingame lies in a synclinal trough of mild inclination, which has carried the coal much lower than it is elsewhere. The elevation of the coal at Carbon Hill is a little over 1100 feet above sea level, while at Scranton five miles to the southwest it is nearly a hundred feet lower, and at Burlingame ten or eleven miles to the southwest of Carbon Hill it occupies a position little if any over 950 feet above sea level. From here to the south it rises, being about 1025 feet at Osage eight miles to the south, and 1125 at Lebo twenty miles further. From here to the southern part of the state the coal at its various points of outcropping gradually declines, being 1050 feet above sea level at Eureka. North from Carbon Hill it also declines towards Topeka, but from there to the northeast it rises gradually to the northern part of the state. This Burlingame synclinal trough is local in character and only adds a little variety to the monotonously uniform character of the Kansas strata.

Both north and south from Osage county coal has been mined for twenty years or more but nowhere in sufficient quantity to enter the general market. There is a line of mines, irregularly connected, reaching from Carbon Hill northeast by way of Topeka across the Kansas river into northwestern Jefferson,

western Atchison, and eastern Brown counties, throughout the whole of which distance every occasionally some one has opened a strip-pit or a drift or a shaft. In most places the coal has been found to be from 14 to 18 inches in thickness, rarely or perhaps never equaling the thickness it obtains in Osage county.

The conditions to the southwest of Osage county are about the same as to the northeast. Across the line in Coffey county in the vicinity of Lebo comparatively large amounts of coal are still being mined, the product for 1897 reaching about 10,000 tons. Here the mines are principally strip pits or drifts. The coal largely supplies the local trade and is used also by the Santa Fe Railway Company to a limited extent along its Emporia branch. Southwest of Lebo one can almost trace the Osage shales by the piles of debris where mining has been prosecuted all the way from Lebo to the south line of the state by way of Madison, Eureka, Howard, and Leeds.

The total amount of coal taken from the Osage shales cannot be determined definitely, but doubtless reaches into the hundreds of thousands of tons. From 1880 to 1890 the production compared with the whole state production was much larger than it has been since and the actual production likewise was larger. The whole distance from Carbon Hill to Osage City seems to be one continuous mining area. In driving across the country or in riding on the train one is scarcely ever out of sight of the piles of debris produced by the mining operations. Recently there has been a decline in the output on account of the excessive production in Cherokee and Crawford counties. With the current prices in the southeast coal can be shipped into Osage county at such low figures that mining here scarcely is profitable, particularly in view of the fact that the southeastern coal is quite superior in quality.

What the future will reveal from the Osage shales can only be surmised. The amount of coal now in sight in this region is many times as great as that which has already been removed. Should the price increase only a few cents a bushel the Osage shales could supply the whole state for centuries even though the demand should be much greater than it now is.

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HORSEBACKS OF THE KANSAS COAL MEASURES.

"Horsebacks" as certain peculiar formations occurring in Kansas coal measures are called, are not only interesting when considered geologically, but also play a most important part in the economy of coal mining. The name "horseback" or "hog-back" was probably applied to these formations on account of their peculiar rounded upper extremities, yet it might have been taken from the term "horse" as applied to an enclosed mass of "country" rock in a metalliferous vein.[4] At various times and in various places the following terms have been applied to these formations, "horse," "want," "trouble," "nip," etc., and most applicable of all "clay veins".[5]

Localities.

"Horsebacks" are by no means confined to the Kansas coal fields, but are found in great abundance in the Coal Measures of Pennsylvania, in particular, and in several adjoining states. In fact there are few, if any, coal mining localities known in America where they do not occur. In our own state they have been studied by the writer in Cherokee, Crawford, Bourbon, Linn, and Osage counties. They diminish in size and frequency of occurrence in passing to the north and west and occur most abundantly in the Cherokee shales of the southeastern part of the state. The same horizon reached by the coal mining operations at Leavenworth shows no trace of these peculiar formations, but furnishes another phase of the same difficulty which the "horseback" presents to the mining operations, namely, the "pots," "kettles," or "bells," met with in the mines at the extreme northern limit of the workable coals of the Cherokee shales. These formations will be considered further on. "Horsebacks" are found in the Osage shales, but are not numerous. They seem to be merging into another form, called "rolls and slips," but which are also called "horsebacks" throughout the mining localities of the state.

4. "Ore Deposits," J. A. Phillips, p. 35.
5. Pa. Second Geol. Sur. Rep., H., p. 27.

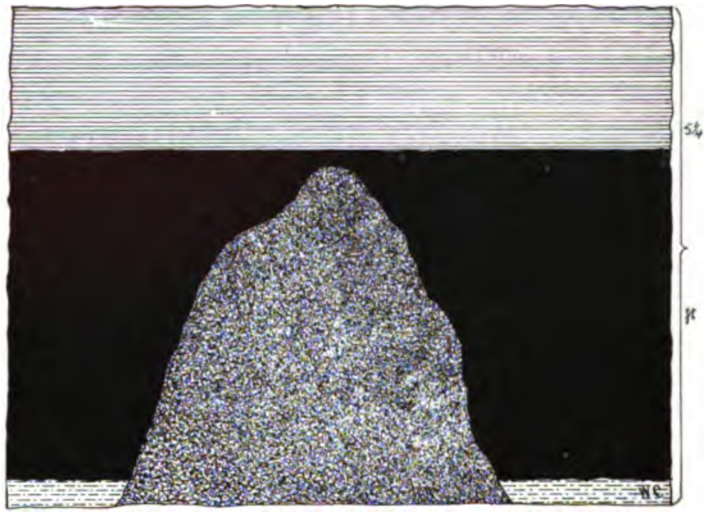


FIGURE 12. Typical Horseback or Clay Vein, as seen in Mine near Pittsburg.

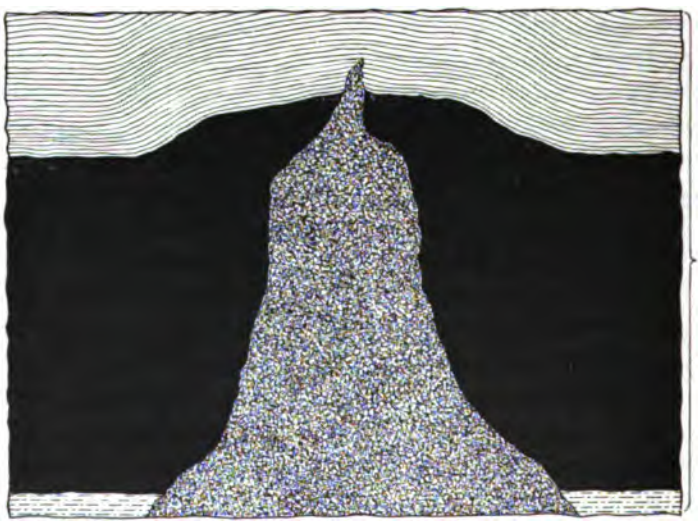


FIGURE 13. Horseback, showing the Upward Bulging of the Coal and Shale.
(Reproduced from the Kans. Univ. Quar., vol. iv, p. 146, Lawrence, Jan. 1896.)

INTERSECTION OF HORSEBACKS 1 AND 2,

As seen in Nesch Brick Yards, Pittsburg. (Photographed by Crane, 1897.)

INTERSECTION OF COAL AND HORSEBACK,

As seen in Mine in Weir City. (Photographed by flash light by Crane, 1897.)

Nomenclature.

There seems to be a slight lack of harmony in the usage of the above mentioned term, especially in the different states.[6] For instance, in Kansas the term "horseback" is applied strictly to clay filled, almost vertical fissures which pass through the coal. In Pennsylvania such clay filled fissures are called "clay veins." Again in the coal fields of this state a dipping down or a bulging up of the strata from above or below the coal, especially the former, is called a "roll in the slate" of the roof. This phenomenon is given the name "horseback," "nip," "want," etc., in the Pennsylvania collieries. The nomenclature adopted by the Pennsylvania miners and geologists seems most applicable and will therefore be used in this report.

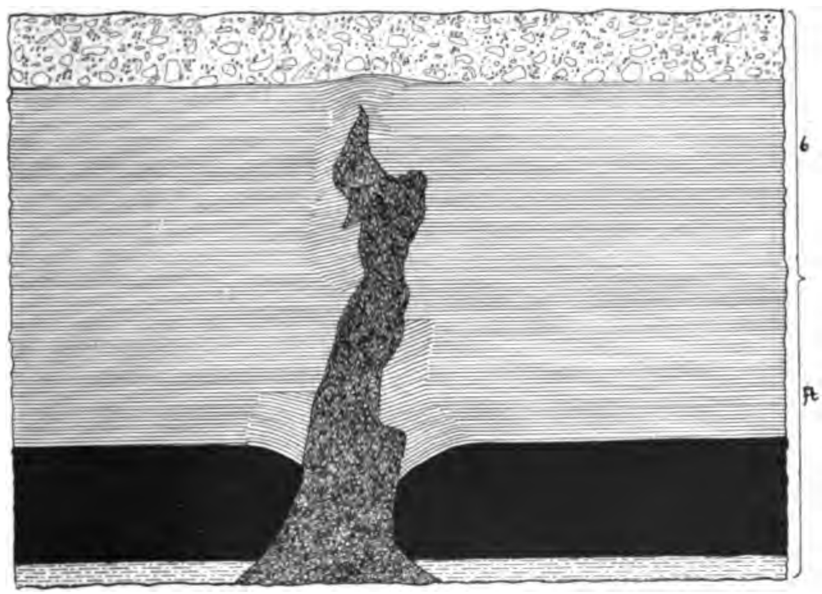


FIGURE 14. Horseback, showing Bulging of Strata due to Lateral Compression. (Reproduced from the Kans. Univ. Quar., vol. iv, p. 147, Lawrence, Jan. 1896.)

6. "Clay Veins Vertically intersecting Coal Measures," W. S. Gresley, p. 36.

Characteristics of Horsebacks.

Forms of the Fissures.

The "horsebacks" or "clay veins" of Kansas seem to be clay filled fissures formed after the coal was consolidated. They trend in many directions with apparently no regularity. So far as has yet been observed the direction of individual fissures is wholly irregular, but a line trending northeast and southwest seems to strike a larger proportion of them than would a line in any other direction. The fissures usually are narrow, averaging perhaps less than five feet as they are found in the coal. Plate XXXII. They generally pass through the coal and into the shale above, often reaching almost to the surface, but sometimes thinning to a mere fissure with no apparent thickness only a few feet above the coal. Figures 12 and 13. At other times they do not pass entirely through the coal from below, while still again in much rarer cases they seem to be passing downward from above. Figure 14. The downward extent of the fissures in most cases is entirely unknown, as coal mining operations do not follow them much below the coal itself.

The fissures often bifurcate, or in some cases split into three or more branches, in both horizontal and vertical directions. The hade is generally but a few degrees from the vertical, and perhaps a large majority of them hade less than thirty degrees from the vertical, but occasionally one is found making an angle as high as eighty or eighty-five degrees.

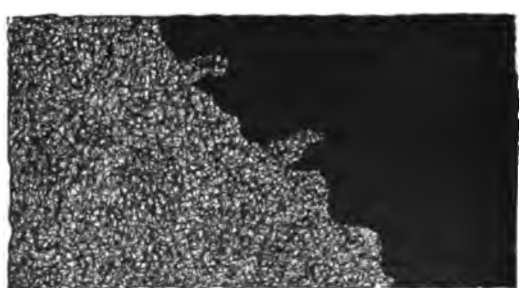


FIGURE 15. Irregular Contact Line between Horseback and Coal, as seen in a Strip Pit near Pittsburg.

Nature of the Walls.

The walls of fissures are usually rough and ragged, but sometimes are smooth and polished, presenting well formed slickensides. Figures 15 and 16. This property is even present in the walls of the coal itself in some instances, although not so strongly marked as the fissure walls in the shales and clays. Usually

FIGURE 16. Regular Contact Line between Horseback and Coal, as seen in Strip Pit near Pittsburg.

the coal walls are rough and jagged with the irregularities of one side corresponding closely to those on the other, implying that the coal had been broken asunder and separated horizontally, while in rare cases a vertical displacement of a few inches or a foot has taken place. Frequently angular fragments of coal have lodged in the clay filling, as though it had dropped from the roof wall during the process of filling. Figures 17, 18, 19, 20, 21, and 22.

The horizontal position of the coal or shale strata usually has not been disturbed, but in some cases the strata adjacent to the fissure have been lifted up as though after the fissure was formed and filled with the clay a lateral compression occurred with a slight bulging upward of the ends of the strata in contact, as represented in Figure 23. In several instances quite noticeable folding of the strata of both coal and shale have been noticed, "horsebacks" are almost always associated with such folding.

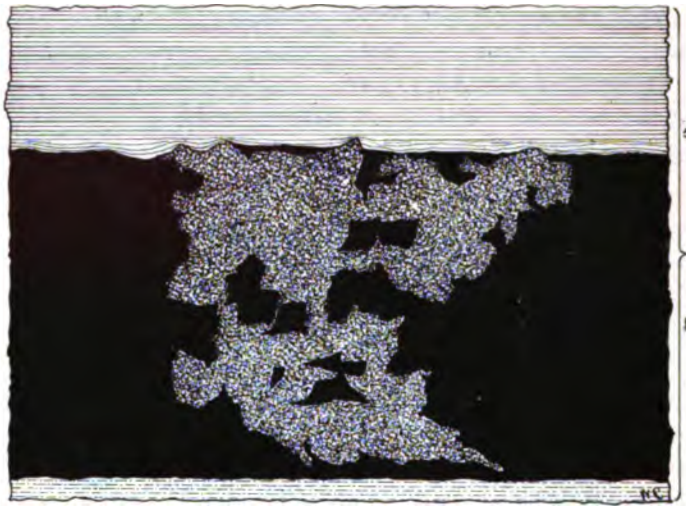


FIGURE 17. Horseback, showing Fragments of Coal scattered through the Fire Clay, as seen in Mines near Pittsburg.

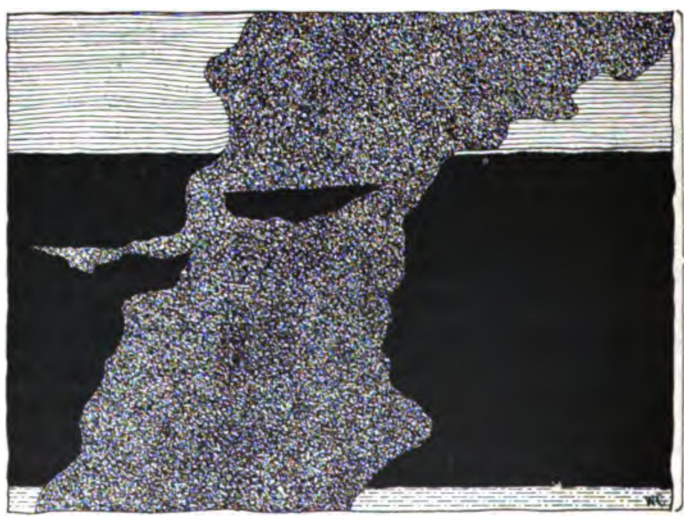


FIGURE 18. Horseback intersecting Coal Stratum, showing Fragment of Coal in Matrix. Pittsburg.

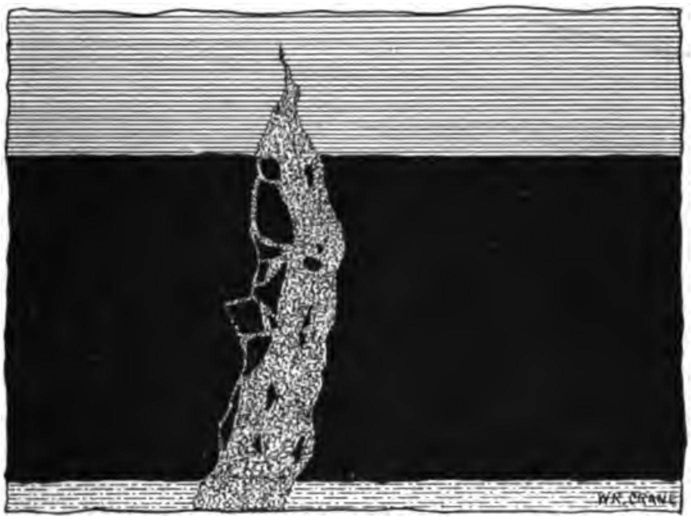


FIGURE 19. Horseback, showing Fragments of Coal in Fire Clay, as seen in Mines near Weir City.

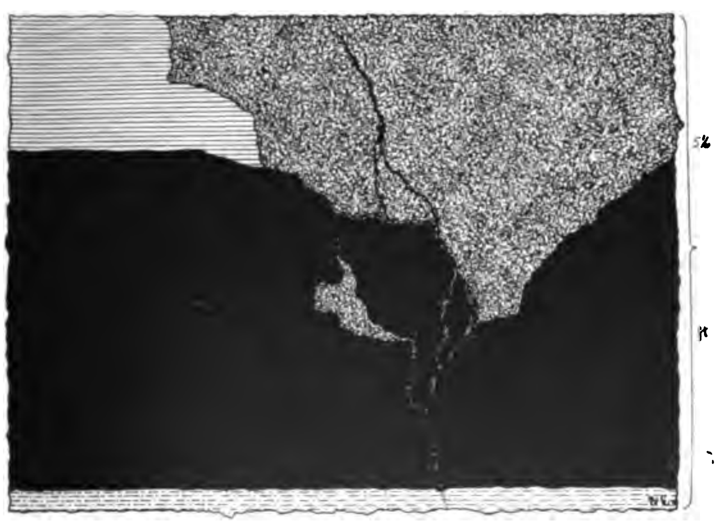


FIGURE 20. Horseback protruding into Coal Stratum from above, as seen in Mines North of Pittsburg

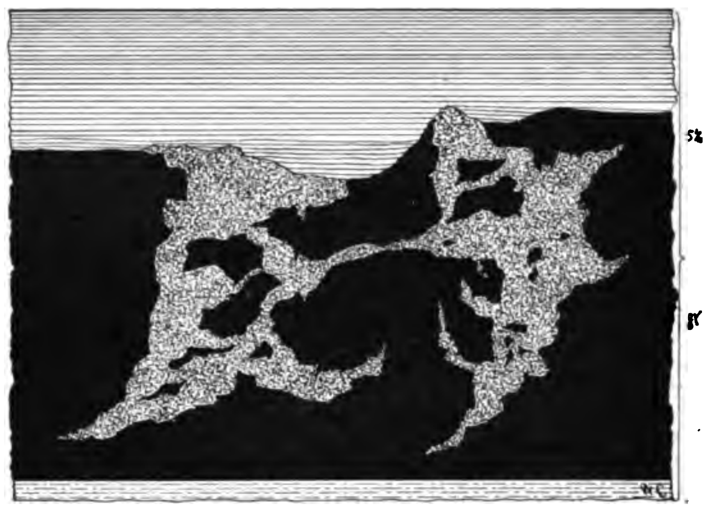


FIGURE 21. Horseback, showing Fragments of Coal scattered through Fire Clay, as seen in Mine North of Pittsburg.

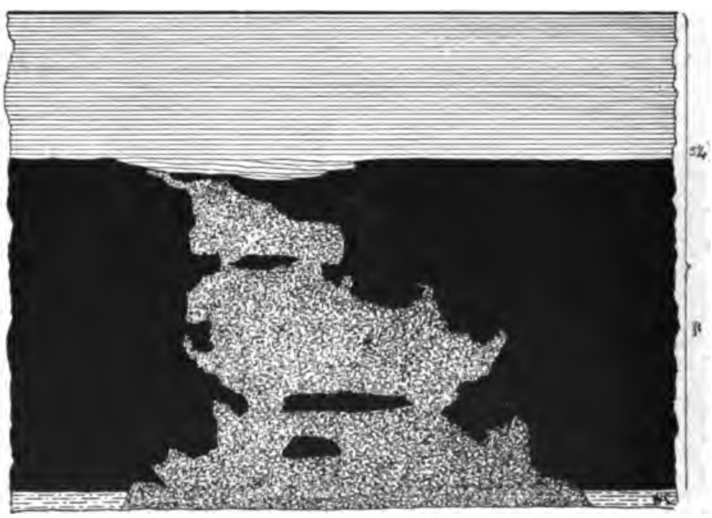


FIGURE 22. Horseback, showing Fragments of Coal scattered through the Fire Clay, as seen in Mines near Weir.

There is still another peculiar feature of the arrangement of the walls, namely, when the upper surface of a coal stratum is bent upward on one side of a clay vein, it is almost always bent downward on the other side of the vein, although the bottom of the coal on either side may not be altered in position. The coal stratum is therefore pressed into a very small space — nearly pinched out, on one side, while on the other side of the clay vein it is very much expanded and broomed out.

Extent of the Fissures.

The extent of the fissures, both vertically and laterally, can hardly be determined. The processes of mining operations are confined to so small a distance vertically that the fissures cannot be studied below the coal to any considerable extent, and the tunnels and driveways are made in such a way and the mines located in such position that it is also very difficult, or in fact impossible, to find the lateral extent of many of the fissures. It is known that some of them extend continuously for half a mile or more, but beyond this it is largely conjecture, although it is probable that many of them extend much farther.

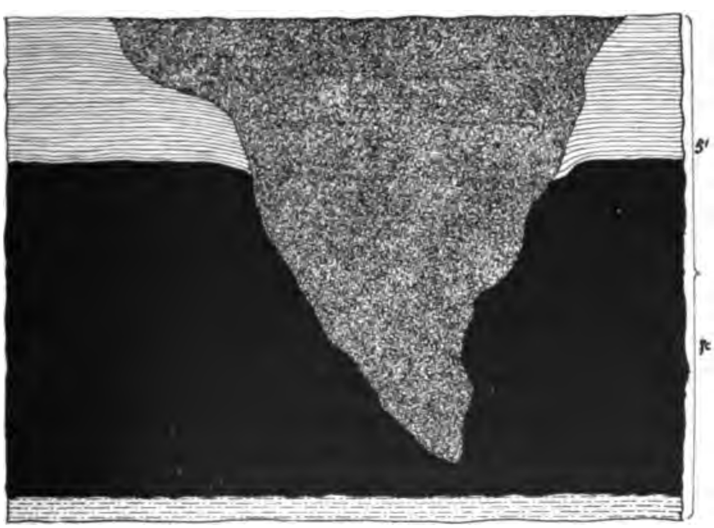


FIGURE 23. Horseback protruding into the Coal from above.
(Reproduced from the Kans. Univ. Quar., vol. iv, p. 145, Lawrence, Jan. 1896.)

Contents of the Fissures.

The contents of the fissures in most cases is a low grade of fire clay produced from adjacent shales by the ground waters leaching out the iron compounds. In a few instances the clay filling contains fragments of coal, or of sandstone similar to that which may be seen in the shales above, implying that the coal and sandstone fragments have fallen into the fissure while the clay was accumulating.

The fire clay is very finely divided, and as a general rule has no regular structure; yet in some cases a lenticular structure is noticed, the convex surfaces of the lens-shaped masses being nearly horizontal. Figure 24. The color of the fire clay is generally light, varying from a light yellow to a pale blue. The general appearance of the fire clay matrix indicates that at one time it was a plastic, semi-liquid, homogeneous mass from which the excess of water has gradually drained away. Before exposure to the air this clay is usually quite hard and tenacious, presenting a formidable obstacle to the miner. But on being exposed to the air it disintegrates and assumes more of the common properties of clay. Where the "clay veins" or "horsebacks" are abundant the "room and pillar" system of mining is usually employed and the masses of clay are used to as great a degree as possible to support the roof.

Crossing of Veins.

Individual clay veins or "horsebacks" are rarely found alone, few veins having been found that are not crossed every few rods and often every few feet by other veins, one vein frequently crossing and recrossing another several times in a relatively short distance. Coal lying between horsebacks close together, usually is of little value, as it is generally badly broken and mixed with the shale or clay above and below, the lesser seams often carrying gypsum and pyrite. Occasionally the clay veins form such a network that the coal is practically non-workable, being so thoroughly broken up and mixed with clay and shale as to render it worthless.

Frequently two or more veins intersect each other. Figure 25, and Plate XXXII. Sometimes one cuts the other same as it cuts the coal and shale, showing a difference in age of the two. In other instances the matrix at the junction of the two veins is broken and mixed into a heterogeneous mass with the surrounding country-rock. In still other cases the matrix at the intersection of the veins does not differ essentially from that found in other portions of the vein. In the former cases the veins are not of the same age — the difference being shown by the structure, color, etc.; in the latter case the veins are of the same age as shown by the homogeneity of the matrix.

Origin of Horsebacks.

Theories of Formation.

Many different theories have been advanced by coal miners and others to account for the origin of horsebacks, clay veins, etc. One theory is that the fissures represent former underground water ways, and that the clay represents silt or sediment of various kinds which the stream deposited in its course, such deposition having been continued until the whole space of the fissure was filled. But how the fissure was produced in the first place the theory does not say. Another theory expressed by different miners is that the clay seams were formed contemporaneously with the coal. Neither of these views seem

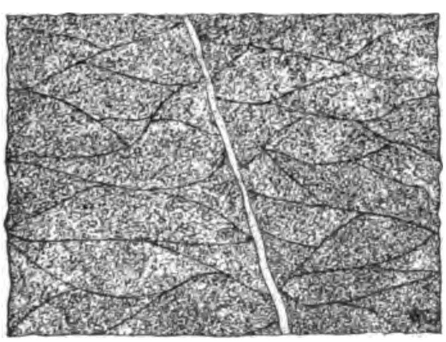


FIGURE 24. LENTICULAR STRUCTURE OF MATRIX OF HORSEBACK, also showing an intersecting Seam of Sandstone, as seen in Strip Pits near Pittsburg.

to correspond with all of the observed facts, consequently it cannot be concluded that either of them is correct. Before giving the view of the writer let us glance hurriedly once more at the conditions actually observed.

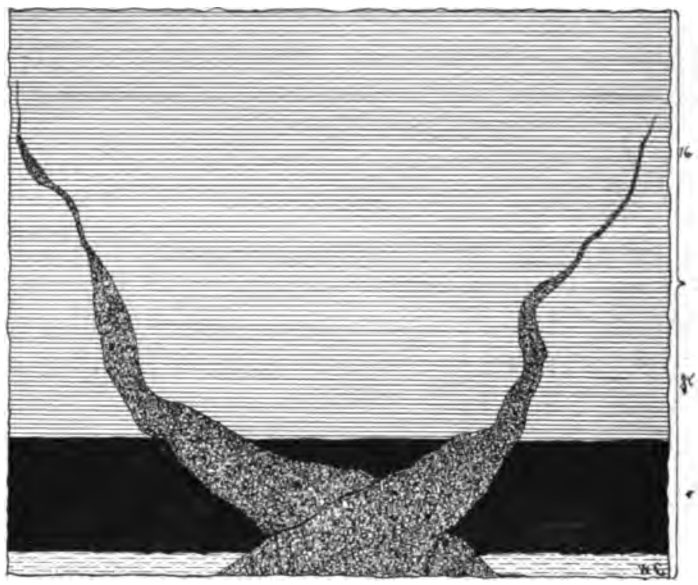


FIGURE 25. Crossing of Horsebacks, as seen in Strip Pits near Weir City.

Observed Phenomena.

After examining a large number of mines and strip pit workings in the southeastern part of the state where the clay veins are quite numerous, the following facts there observed may be summarized:

1. The walls of the clay filled fissures present a rough fractured surface as if they had been broken and torn apart by a horizontal stretching process which was greater than the coal beds could endure. Figures 26, 27, and 28, and Plate XXXIII. In some cases the layers of coal are pressed upwards near the upper surface and downwards near the lower. Figure 29.

2. There is always an upward displacement of the shale at the upper extremities of the clay veins. Figures 23 and 30.

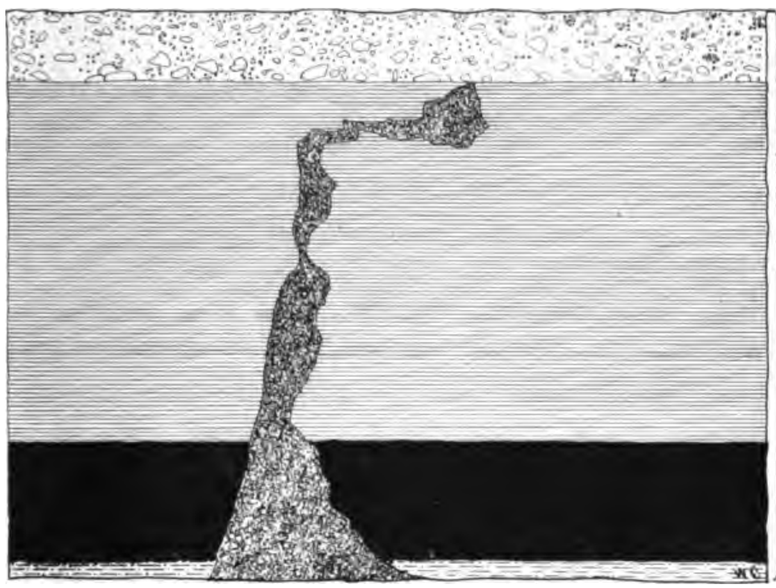


FIGURE 26. Horseback in Coal and Shale, showing Stretching Effect of Earth Movements, as seen in Strip Pits near Pittsburg.

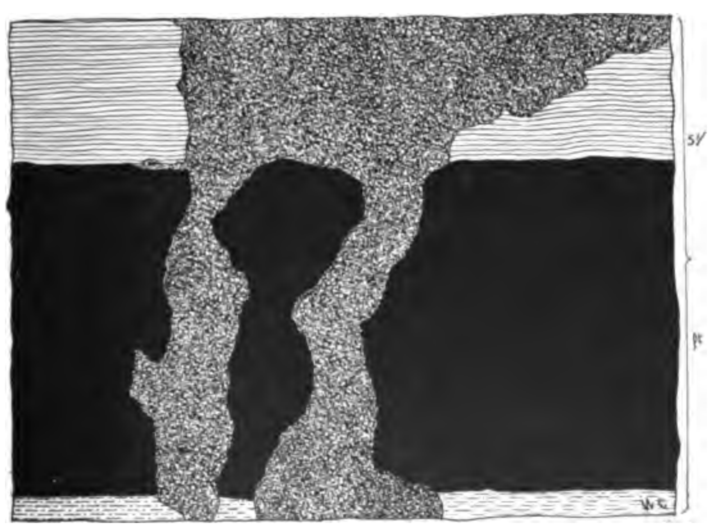


FIGURE 27. Horseback intersecting Coal and Shale Strata, showing Stretching Effects of Earth Movements, as seen in Mines near Pittsburg.

Displacement, especially in the coal, is attended by fracturing. Figures 17, 30, and 31.

3. The fire clay in the fissure is usually homogeneous and structureless, but sometimes has an approach towards a lenticular structure. In all cases the clay in the clay veins is similar to that underlying the coal, and when the latter is composed of two or more varieties, as a dark and a light one, the same relation exists between them in the clay vein, as shown in Figure 32.

4. Angular pieces of coal are often found mixed through the clay in the fissure. Figures 17, 18, and 19. These are evidently fragments of the original coal bed, for in many places their exact former position can readily be determined by their shape and the appearance of the wall of the coal. Figures 17, 27, and 21. There is very little broken or finely powdered coal to be found in any of the clay seams.

FIGURE 28. Horsebacks in Walls of Entry, as seen in Mine at Weir City.

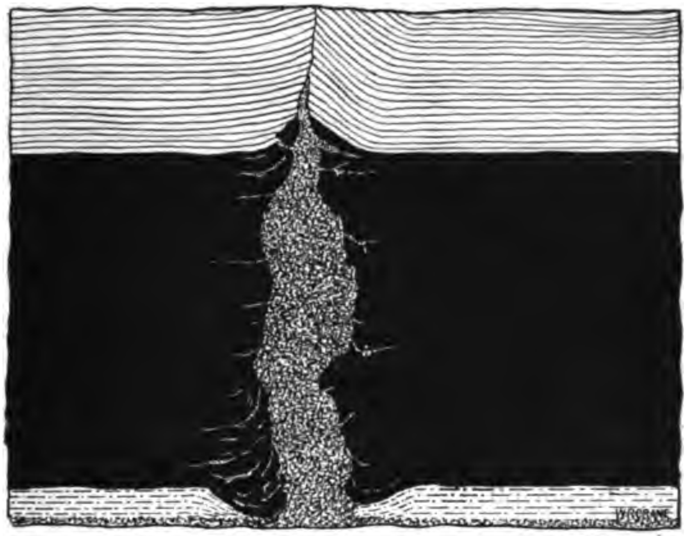


FIGURE 29. Horseback, showing upward and downward Displacement of Coal and accompanying Strata.

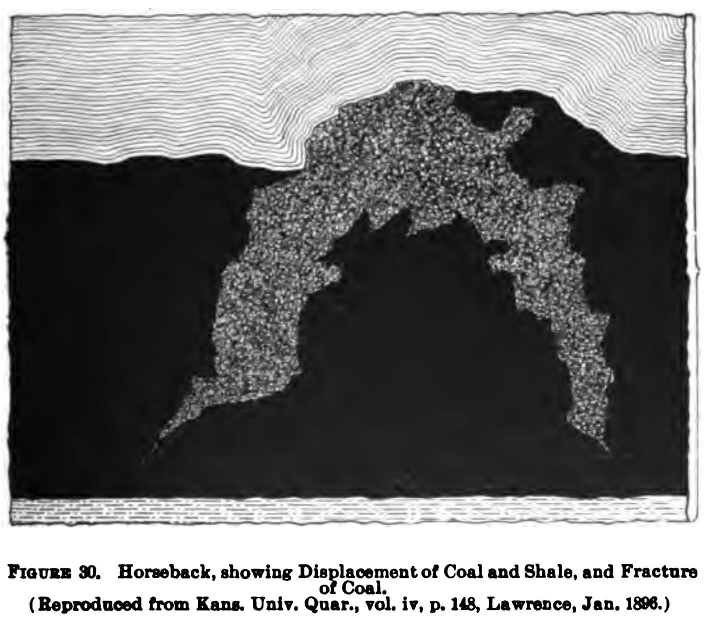


FIGURE 30. Horseback, showing Displacement of Coal and Shale, and Fracture of Coal.
(Reproduced from Kans. Univ. Quar., vol. iv, p. 148, Lawrence, Jan. 1896.)

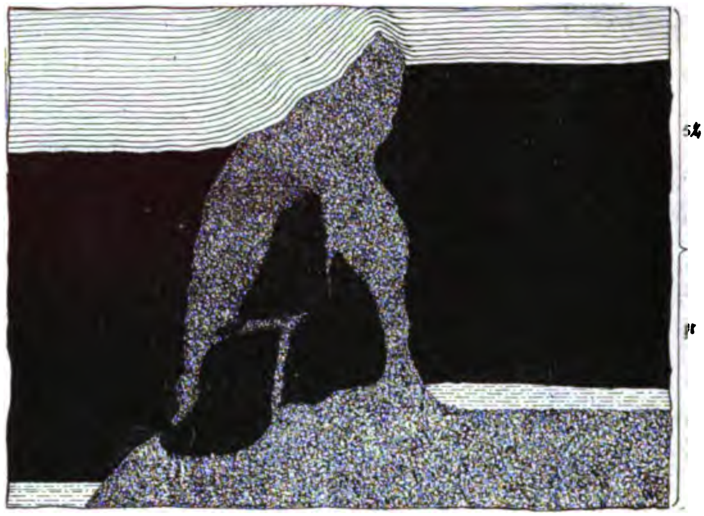


FIGURE 31. Horseback, showing Faulting of Coal and accompanying Lower Strata of Shale, as seen in Mines near Fleming.

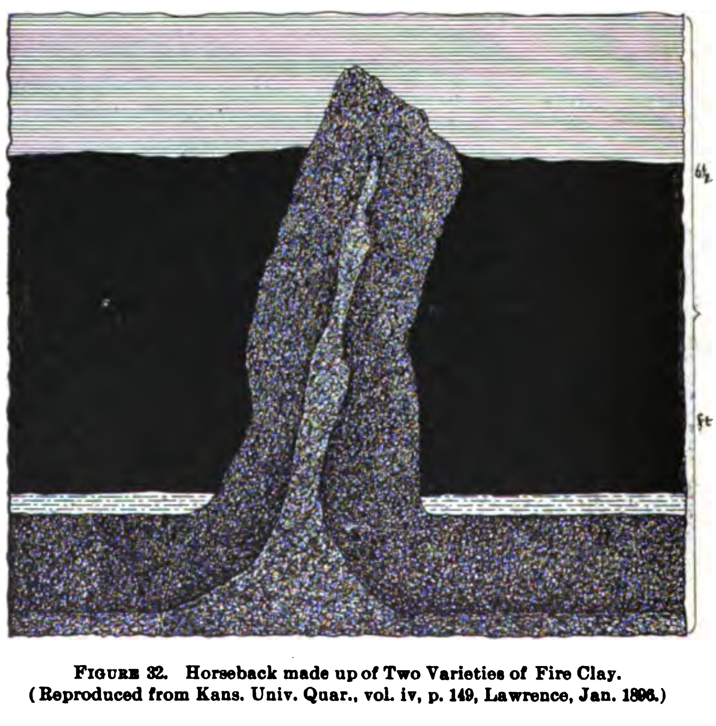


FIGURE 32. Horseback made up of Two Varieties of Fire Clay.
(Reproduced from Kans. Univ. Quar., vol. iv, p. 149, Lawrence, Jan. 1896.)

Probable Origin.

From the observed conditions the writer is led to the following conclusions regarding the origin of these interesting structures. Long after the coal was formed and consolidated almost to its present state, vibratory movements of one kind or another fissured the strata including the coal beds. Figure 33. The great variety of fissures as above described corresponds well with different forms of fissures observed in many parts of the world in connection with the mining of metalliferous deposits. Upon the production of such a fissure the great pressure under which the fire clay at the bottom of the coal had been existing would now be relieved on one or more sides. If the fissure passed entirely through the fire clay the surface of each wall would be relieved of pressure; if it only reached downward to the fire clay the upper surface would likewise be relieved of pressure. Considering the exceedingly unctuous property of clay and the softening to which it would be subjected from time to time by the underground water, it is very easily understood how it would soon move upward sufficiently more or less completely to fill the fissure produced by the earth's tremor. This process would simply be an exaggerated case of ordinary "creeping" so commonly known in the underground workings. The upturning of the shale laminæ near the upper part of the fissure would very readily be produced by the upward movement of the clay acting under the great power which was forcing it along, while the occasional fragments of coal and sandy shale found within the clay veins can readily be accounted for by the occasional dropping of a block which was almost broken under the first earth movements which produced the fissures.

The vibratory movements producing so many fissures must have been comparatively gentle in character as few vertical displacements of any consequence have been recorded. Also the general results were of a nature to elongate and stretch the strata horizontally rather than to compress them. The aggregate increase in horizontal dimensions has not been determined, as the mining operations have covered but a few miles in an east and west direction. But from the large number of clay

veins with an average width of from three to five feet it can be seen that the actual increase in horizontal dimensions has been very considerable. These fissures are best recorded in the coal beds because of the brittle nature of the coal. The clay veins well illustrate nature's method of filling up and obliterating fissures of this general character when produced in ordinary shales, although the latter may be interbedded with limestones.

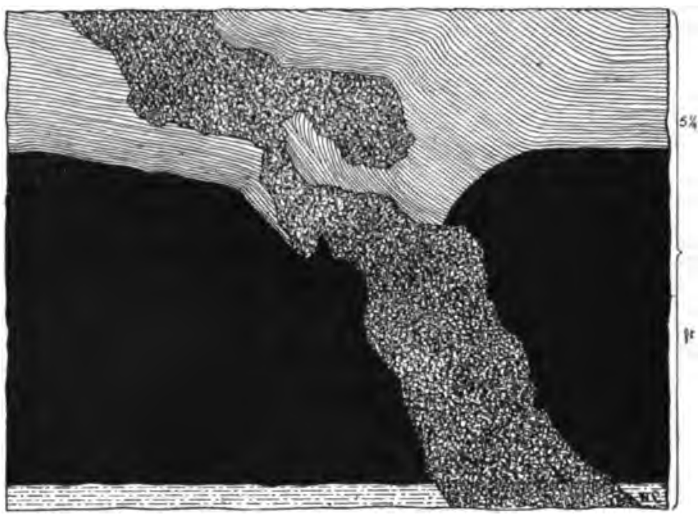


FIGURE 33. Horseback, showing well defined Fissure, which the Fire Clay has filled, as seen in Mines near Pittsburg.

The age of the clay veins cannot be determined by internal evidences. It is possible that they were produced at various periods separated by considerable time epochs. But it is probable that the greater number of them and the more important of them were produced at the time of the Ozark uplift to the southeast. The general character of this uplift seems to have produced a dome shaped elevation which would require an elongation of horizontal dimensions. The stretching of strata so marked is therefore accounted for. A careful study of the horsebacks shows that their prevalent direction is northeast and southwest, approximately tangental to the Ozark dome, with the next most common direction nearly at right angles to

this. The greatest fault observed is a vertical displacement of about 8 feet exposed in a mine of the Mount Carmel Coal Company. Great as this displacement is it is surprising that so few other displacements have been found. It may incidentally be remarked that the general direction of these fissures is nearly parallel to the most prominent fissures in the lead and zinc mining district to the southeast, which adds to the probability of all of them having been made at the time of the Ozark uplift.

"BELLS" IN THE KANSAS COAL MEASURES.

Certain structures disadvantageous to mining operations occur in the shale or roof over the coal and are known as "pots," "kettles," "bells," etc. As the names imply, the structure is circular in form, horizontally, and pot shaped, bell shaped or kettle shaped vertically.

Localities.

Bells are not found very abundantly in the coal fields of the state, and are not scattered over a very wide area. They are found principally in the Cherokee shales at the coal mines of Leavenworth and vicinity. They are rarely found in the same horizon to the south. In passing westward through the coals of the different horizons, formations bearing such a close resemblance to the bells that they are often so called increase in number, yet the number found is so small and the inconvenience caused by them so slight that they are seldom mentioned by miners and mine operators.

Nomenclature.

The names "pot hole" and "kettle hole" are commonly applied to circular holes eroded by currents in flowing water. These holes filled in turn by sediment produce forms called "pots," "kettles" and "bells." The formation found in the coal measures bearing a close resemblance to the true "pot" and "kettle" holes found in various parts of the world probably received its name on account of the similarity existing. If this formation received its name through an imagined resemblance to a "pot," "kettle," or "bell" then it should receive

the name of the article which it most closely resembles. As most of the formations examined by the writer more closely resemble a bell than either a pot or kettle, we will employ the term "bell" when speaking of the same hereafter.

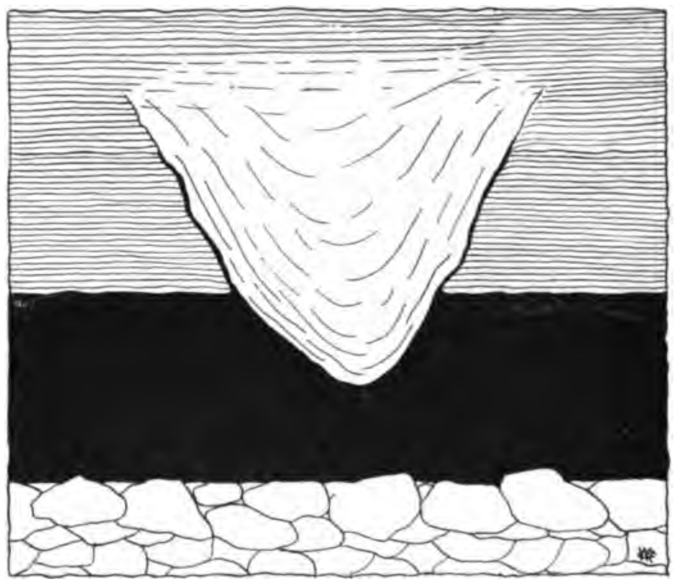


FIGURE 34. Typical Bell, as seen in the State Mine at Lansing.

Characteristics of Bells.

Form of Bells.

The forms of the bells are not much varied. The essential features of the variation are a horizontal and vertical shortening and lengthening, thus producing narrow, deeply projecting, and broad, widely extending, but relatively thin bells. The two forms above mentioned are the ones usually met with, although there are a large number of intermediate forms. The bells are usually rather small, averaging probably four feet in diameter. They extend in a vertical direction generally, but a few cases have been noted where they extend downward obliquely, seldom making an angle with the vertical exceeding 45 degrees. Figure 34. They pass downward from

above, protruding into the coal several inches — seldom less than six or eight, and more often a foot or two; and it is not an infrequent occurrence for them to pass entirely through the coal. In much rarer cases the bell is reversed — Figure 35 — the base protruding into the coal while the apex extends upward into the superincumbent shale. In such cases they produce what is more often called a "roll." Figures 36 and 37. This is rather a dangerous form as the roof is liable to cave in, but due to the scarcity of this form of bells few or no accidents occur on account of them.

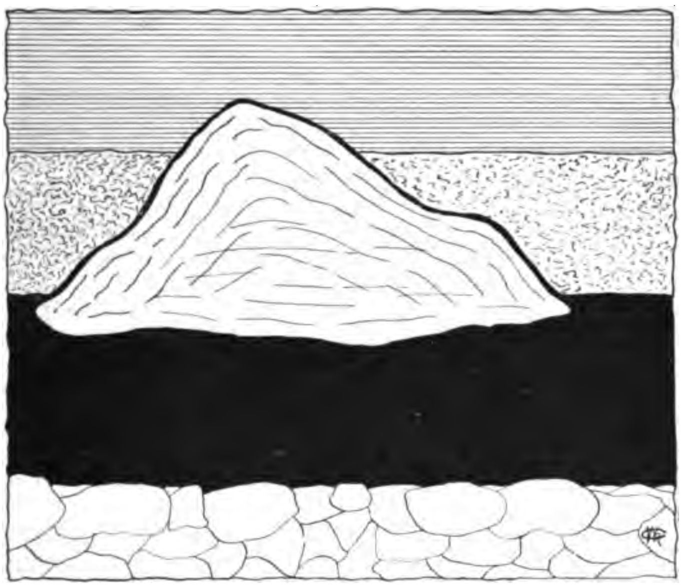


FIGURE 35. Inverted Type of Bell, as seen in Mine West of Prescott.

Nature of Lateral Portions.

The sides of the bells are as a rule very smooth and polished. The coal adjacent to the bell is also very smooth. There is nothing in connection with the bell or adjacent coal to indicate that there has been any displacement. The laminæ of the coal show no signs of having been displaced by lateral or vertical pressure, but extend up to the bell where they stop abruptly,

but continue again on the opposite side without any apparent break in their order.

No fragments of coal as yet, to the knowledge of the writer, have been found in the matrix of the bell.

A very peculiar feature which should be mentioned here is that the seam produced by the junction of the coal and bell often extends upward into the roof at approximately the same angle that it makes with the vertical in the coal. This seam becomes more narrow as it passes above the stratum of coal, producing a well defined fissure — Figures 34 and 35 — which is always filled with coal that has attained a remarkable degree of hardness and luster, and is an excellent quality of anthracite coal. (See Table IV, *post.*) In several cases noted this thin layer of coal passed entirely over the bell — this was in the case of an inverted type. Figure 35. The coal filling these fissures does not constitute a sheet or layer of uniform thickness. On the contrary it is very uneven, varying from a film to three-quarters of an inch in thickness, with a very smooth surface.

Extent of Bells.

The extent vertically and horizontally can quite readily be ascertained as the bells seldom reach further than through the coal, and often in dressing down the shale of the roof all traces of the bell are removed. The horizontal extent is seldom more than eight or ten feet.

Contents of Bells.

The matrix of the bell is shale — the same as that composing the roof, differing not in the least in structure or color from the adjacent shale, except that the matrix is not laminated in the same plane as the shale above and on the adjoining sides. No lines of lamination are visible until acted upon by the weather or struck by hammer, whereupon shell-like portions generally about three-fourths of an inch to two inches in thickness will fall off, disclosing concentric planes of lamination. There seems to be a larger number of fossil invertebrates in the matrix of the bell than in the surrounding shales.

If the bells occurred as frequently as the horsebacks of the

southern coal fields they would necessitate the employment of the "room and pillar" system of mining, but fortunately they are not very numerous.

Origin of Bells.

Theories of Formation.

Several theories have been advanced to account for the formation of these bells. One is that they are holes washed in the coal by rotary currents formed in the water during the formation of the coal, and afterwards filled with the same material which now constitutes the roof of the coal. Another is that

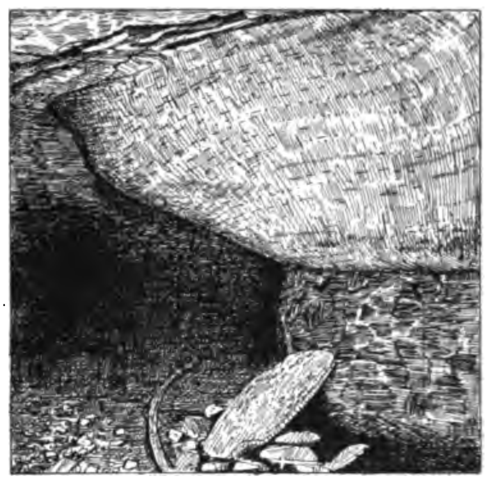


FIGURE 36. A "Roll" in the Roof, as seen in Mine at Weir City.

they are due to the giving way of weakened portions of the roof strata, thus producing a settling into the coal. It might be well to summarize the facts observed.

Observed Phenomena.

1. The lateral parts of the projecting body are smooth and even, often being marked with creases, which always extend in a vertical direction. These creases are similar to those ob-

served when two pieces of wood or rock masses are caused to slip one upon the other when under high pressure.

2. The laminæ of the coal have not been disturbed.

3. The character of the contents does not differ from the adjacent shales of the roof.

4. The laminæ of the contents of bells are in the form of concentric circles or ellipses — that is, always parallel to the outside of the bell.

5. There is a larger number of invertebrate fossils in the matrix of a bell than in a corresponding portion of the adjacent shales.

6. The seam produced by the junction of the coal with the bell often extends upward into the overlying shale strata. When this occurs the fissure is always filled with coal, which has been changed to anthracite.

7. No coal or rock has as yet been found in the matrix of the bell.

After carefully studying a large number of different forms, the writer has arrived at the following conclusions regarding the probable origin of the bells.

During the accumulation of the coal forming material many conditions may have caused slight irregularities in the amount of accumulated material. A local variation in the growth of the coal plants, a difference in the local water currents of the marsh or swamp, slight eddy currents here and there, the burrowing of water animals if such were possible at that time, or any other sufficient cause whatever may have obtained.

When the sediments constituting the overlying strata were deposited they would cover all such irregularities and the pressure from above throughout subsequent time would tend to depress the roof strata into the openings of the coal. Such a depression would be carried to whatever extent the amount of coal would permit, or until the coal material immediately beneath was compressed to about the same degree of density the coal had elsewhere. In this way portions of the roof for several feet above the coal would be involved.

The concentric lamination of the material within the bell

probably is due to two causes: first, to a partial lamination around the walls of the cavity as the sediments were accumulated; and second, partially to a pseudo-lamination set up by the downward movements of the strata as the coal was being compressed.

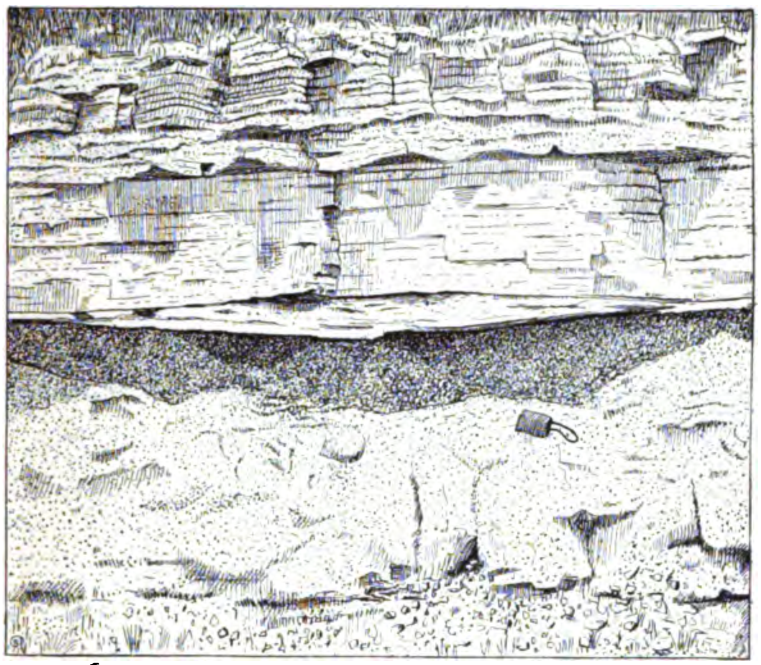


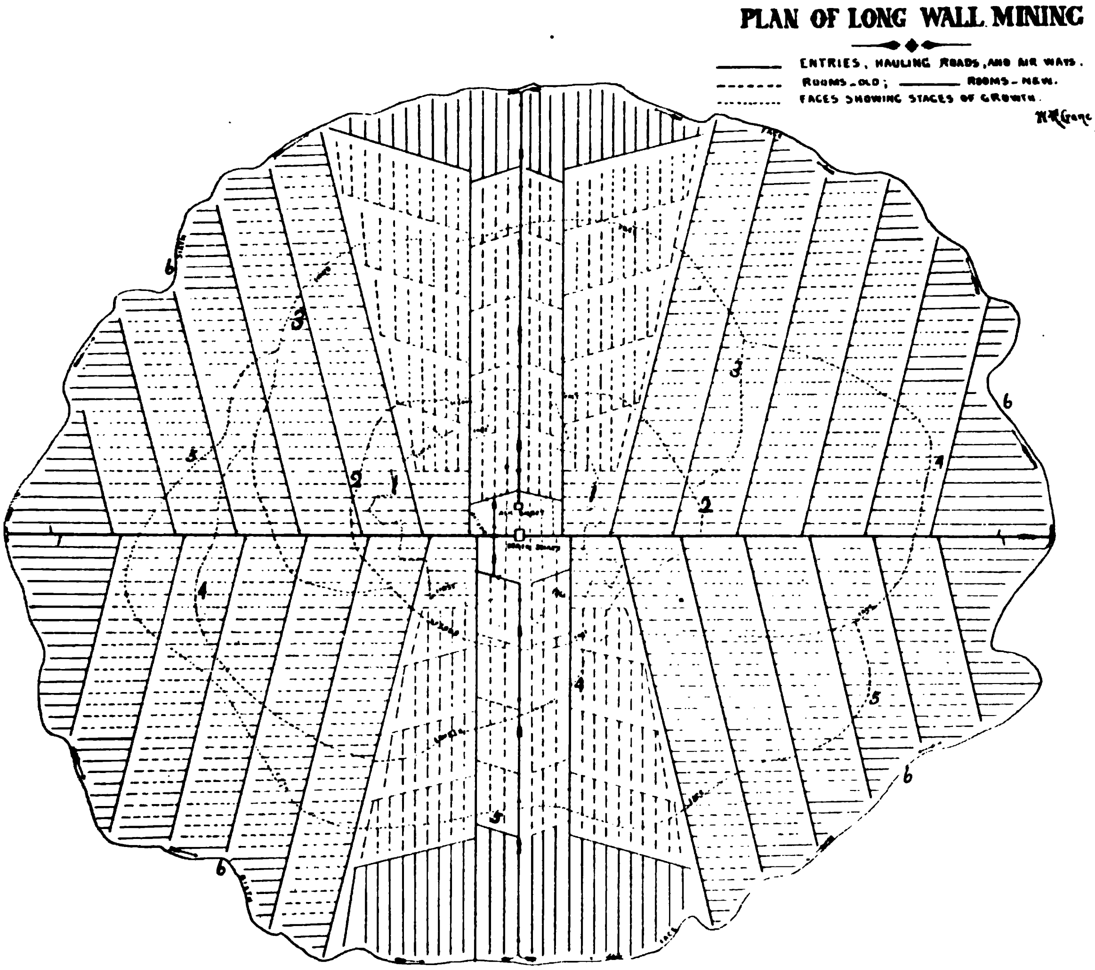
FIGURE 37. A "Roll," as seen at Fort Scott.

The larger number of fossils within the bells likewise indicates that there was a depression or pot-hole structure in the upper surface of the coal material during the period of coal formation, in which the shells accumulated by the movements of the invertebrates while alive and by the subsequent drifting in of their shells by waves and water currents.

The fissures in the overlying shales forming continuations of the outer walls of the bell would naturally result from the shearing of the roof strata as the downward settling occurred.

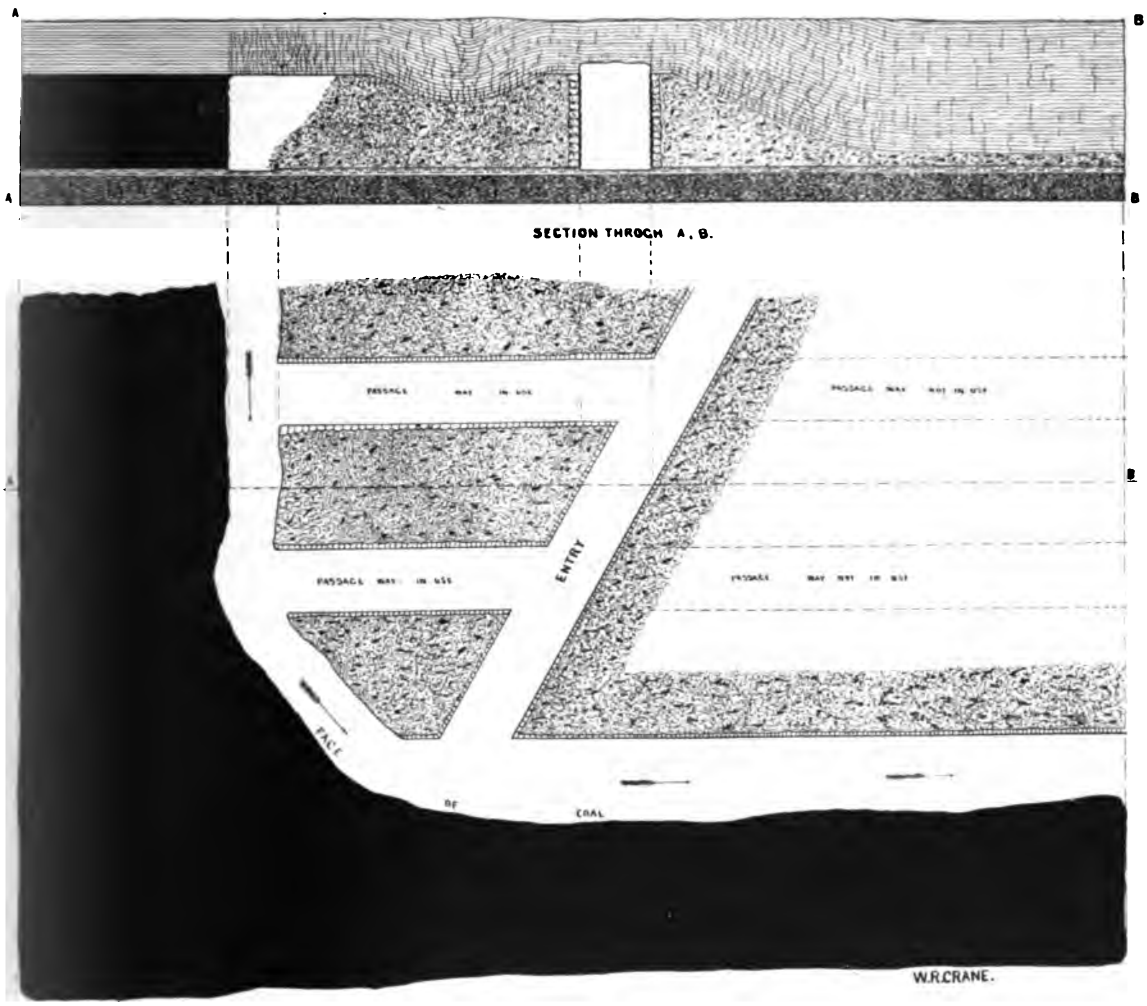
The creases and corrugations on the outer walls of the bell likewise were produced at that time by the downward movement.

The presence of thin laminæ of coal within these fissures can be accounted for by presuming a slight upward movement of some of the coal which, under the high pressure that prevailed and the large amount of water which was present, was forced upward into the fissures. The difference in the quality of the coal in these fissures and that of the coal beds below is a most interesting condition. In some way it would seem this extraordinary squeezing in connection with a slight movement rendered the decomposition of the coal forming material more effective than that which occurred in the coal below. Or possibly the kind of material forced upwards into the fissures was slightly different from the average of the coal and therefore may have been more readily decomposed. Whatever the origin of the bell and the source of the coal material it is a most interesting observation. The presence of genuine anthracite in small quantities in immediate proximity to large beds of ordinary bituminous coal seems to be unknown elsewhere.



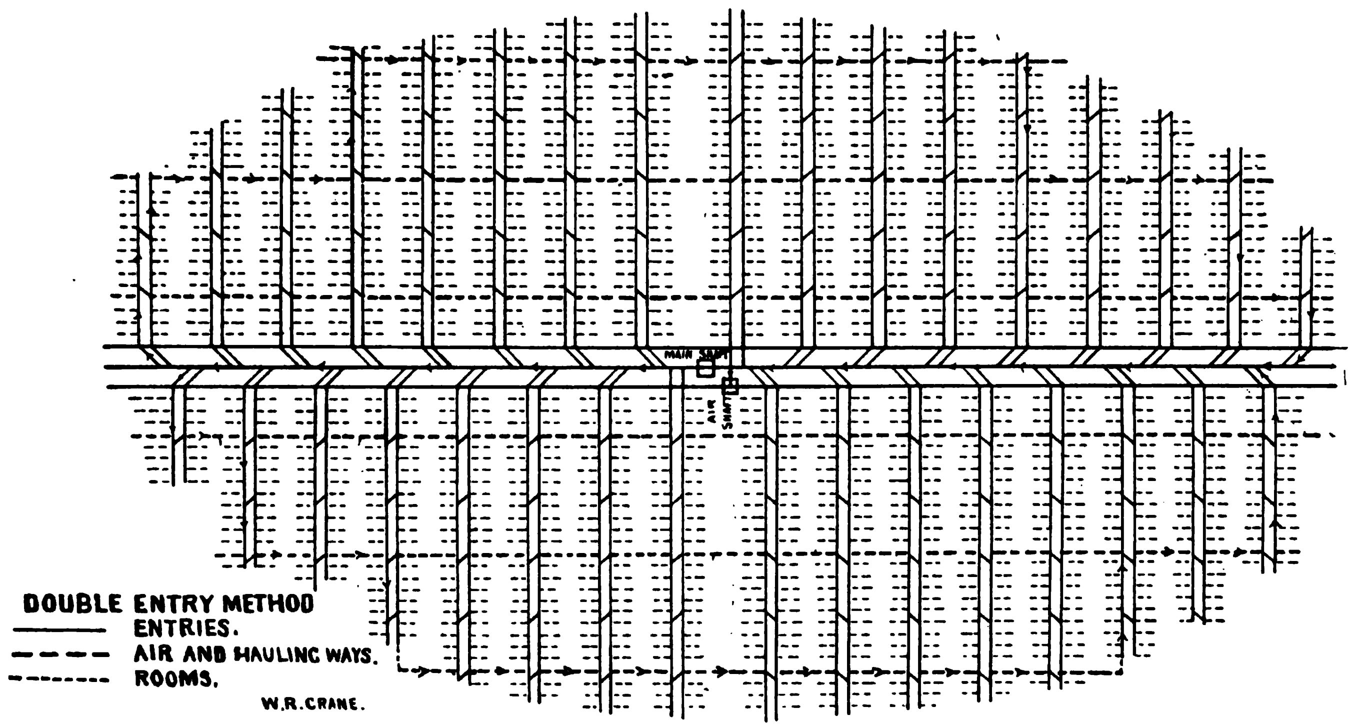
PLAN OF LONG WALL SYSTEM OF MINING.

Heavy solid lines represent entries, hauling roads, and air passages; light solid lines and broken lines represent new and old rooms; numbered dotted lines represent faces of coal at different stages of the growth of mine. Arrows represent direction of air currents and show method of ventilation. This plate represents the system of long wall mining by advancing, that is, the coal is removed, wholly, as the face of the coal advances.

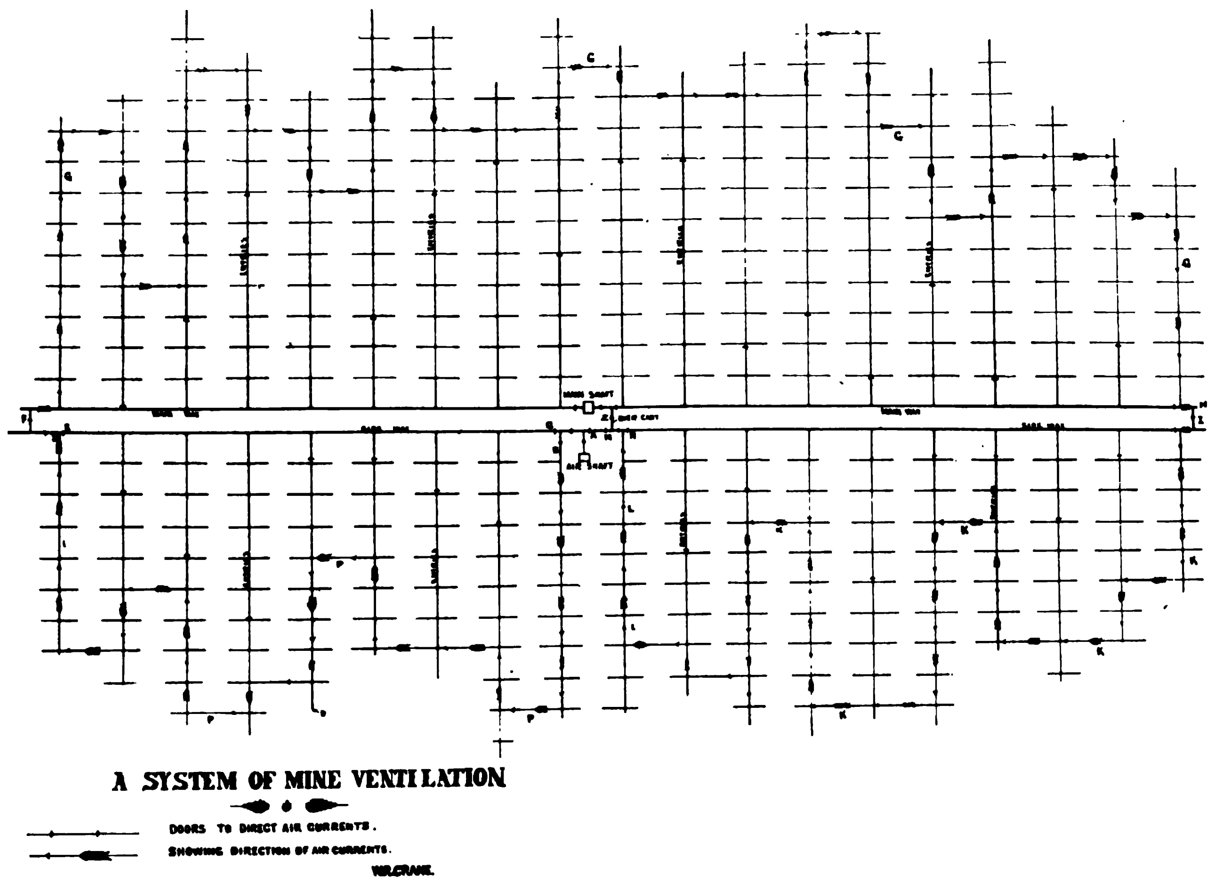


VERTICAL SECTION AND HORIZONTAL PLAN OF LONG WALL SYSTEM OF MINING.

The black represents the coal; the cross-hatched, worked-out portions of mine; open spaces, entries and air passages; and the arrows represent air currents. In the vertical section, the entry is seen open in the middle of section; the opening for mining operations and air passage is seen next to face of coal at the left-hand side. The gob or wall-packing is also shown in the vertical as well as horizontal section and plan.



DOUBLE ENTRY METHOD—ROOM AND PILLAR SYSTEM.



PLAN OF SINGLE ENTRY METHOD, ROOM AND PILLAR SYSTEM, SHOWING SYSTEM OF MINE VENTILATION.

The heavy line passing through main shaft is the main entry or way, the heavy line parallel to it represents the side way. Perpendicular to these entries are side entries, used for hauling roads and air passages. On each side and perpendicular to these side entries are rooms, represented by the cross lines. The arrows show the direction of the air currents and, taken together, show the system of ventilation.

SYSTEMS OF MINING EMPLOYED IN KANSAS COAL FIELDS.

There are three systems of mining generally employed in the coal fields of the state, namely: The Long Wall system, the Room and Pillar system, and the Strip Pit system. The greater part of the coal mined in Kansas is by the room and pillar system, although the long wall system is employed in the larger part, in areal extent, of the coal fields. In Cherokee and Crawford counties the room and pillar system is employed for all underground mining, and also to a limited extent in the vicinity of Pleasanton. Elsewhere the long wall system is exclusively employed.

The system employed at any particular locality is chosen with reference to its greater adaptability to local conditions. The long wall system is employed in coal beds which are comparatively thin, as from 18 to 30 inches, and where the roof is rather weak, soft or brittle; yet this system is often operated where the roof is good and firm, but is seldom put in use where there is a dip of over three degrees. The room and pillar system is employed in coal beds ranging from 3 feet and upwards in thickness. In mining coal of this thickness the waste material would not be sufficient to "pack wall" the roof and a large amount of rock or wooden props would have to be brought into the mine for use as roof supports. For the room and pillar system the roof should be of good material and very firm. The strip pit method of mining is one adopted in all coal fields where the coal stratum comes to the surface and is operated at or near the line of outcrop. It is thus found in operation side by side with the long wall and room and pillar systems.

THE LONG WALL SYSTEM.

The Long Wall system of coal mining is employed principally in the coal fields of Leavenworth and Osage counties, at which localities the system has been studied extensively by the writer. In connection with a study of the following descriptions frequent references to the accompanying drawing is advised. As the name would imply, the face of the coal, that is that part that is exposed to view in the mines by the mining operations, is in the form of a long wall, producing an approximately circular or elliptical figure around the shaft as a center.

The principal advantage of the long wall system over other systems is the ease with which the waste material, obtained in working the coal, is disposed of, it being employed to help sustain the roof. The most essential condition is that there be a sufficient amount of waste to furnish ample material for the "packed wall" or "gob." Timber "cribs" or props are used in connection with the "gob," and in those localities where the coal cannot be removed without considerable loosening of the roof and floor the number of props must be doubled or trebled.

There are two general methods employed in the long wall system, namely: the long wall system by retreating or withdrawing, and the long wall system by advancing.

In the former method gangways or entries are driven to the outer limit of the mine and the coal is then worked back. In this method the main hauling ways and air passages are open to the boundaries of the proposed mine. The real mining operations then begin and continue shaftward until all the coal within the prescribed boundaries has been removed. The method of mining by retreating is practically not employed in this state.

In the latter method, long wall mining by advancing, the coal is removed in approximately concentric rings, the shaft being the center. The mine thus is developed as the coal mining operations proceed, permanent roadways and air passages being opened as the face of the coal is advanced. In this system the coal is wholly removed, the "packed walls" or the walls made

from the loose material obtained in removing the coal, are placed to help support the roof, and the passage ways, entries, etc., are walled up and brushed or dressed down to allow room for mules and cars to pass. Plate XXXIV and Figure 38. This development of the mine continues until the face has retreated to such a distance from the shaft that the hauling of the coal is more expensive than the sinking of a new shaft, or until the limit of the property has been reached.

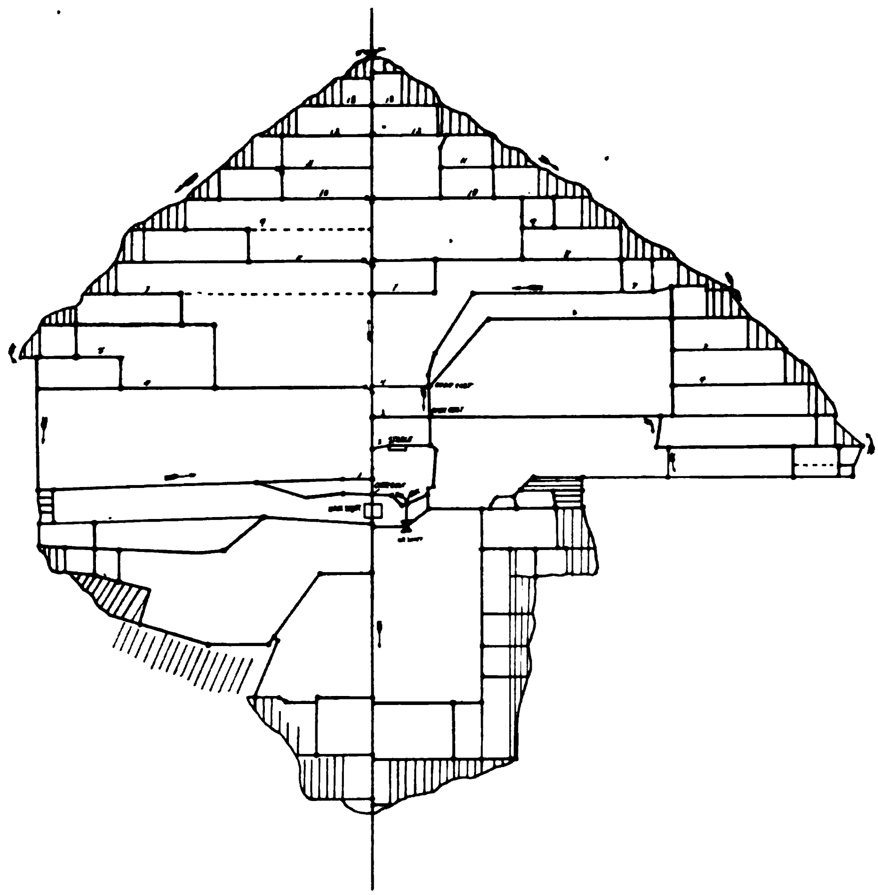


FIGURE 38. Plan of State Mine at Lansing, showing the Progress of the Mining Operations up to the Year 1897. Long Wall System of Mining.

These methods are modified by local conditions of the roof, such as a weak and rather brittle, or strong and flexible, or elastic roof. The advancing method is employed in the Kansas coal fields under almost all conditions of roof.

Long Wall Mining by Advancing.

The shaft is sunk until the stratum of coal is passed through. A hole called the "sump," from 8 to 12 feet in depth, is formed below the coal as an extension of the shaft proper, and is intended as a drainage reservoir for the water of the mine.

Two main entries or gangways are then driven horizontally through the coal, intersecting each other at the shaft at right angles. These entries are usually driven in a general north and south, and east and west direction. Along the main entry on both walls the coal is worked, the "packed walls" being built up as the face of the coal advances. On the walls of the main entry at about a hundred feet from the shaft and at intervals of a hundred feet, side entries are driven. The first two on each side are at right angles with the main entry while those farther away angle away from the entry at an angle of from 110 to 115 degrees.

The coal is generally worked in the side entries running east and west, the north and south entries being used for the hauling ways and air passages. This order may of course be reversed, making the east and west entries the main hauling ways while the coal is removed from the north and south entries. Along the side entries at intervals of forty to forty-five feet, passage ways, as nearly as possible at right angles with the main entry, are walled up to prevent the roof from sinking, and are also "brushed" down, that is the roof strata are removed for several feet above the coal and in the form of an arch, thus making room for the general travel of miners and mules.

There are really no rooms in the long wall system of mining, although the space of forty odd feet between the two passage ways on the side entry are generally designated as such. In a mine where the coal has been removed uniformly in all directions from the shaft the rooms are so located that a miner work-

ing in one room can see the lights of the miners working in the two adjacent rooms on the right and left. The face of the coal is in the form of a long wall extending entirely around the shaft. Plate XXXIV.

It will be noticed that on the east and west entries there are places where the width of the room increases as the face of the coal advances, thus necessitating the gradual enlargement of several rooms or the addition of more rooms. The character of the roof and floor are the factors which generally govern the choice in these matters. If the roof is good and firm the rooms are generally enlarged, even to the employment of two men in one room, but when the roof is weak and brittle the addition of more rooms is preferable.

After the face of the coal has advanced — Plate XXXIV — to a considerable distance from the shaft, cross driveways connecting the entries along which the coal is worked are placed at intervals of from a hundred to two hundred feet apart and are also walled up and "brushed" down, as they are to be used as hauling ways, etc. The coal is then worked from the crossways in a manner similar to that employed in the side entries. Thus the face of the coal is advanced in the neighborhood of two hundred feet, when a new crossway driven at right angles to the rooms worked forms the basis of a new set of rooms, which also extend two hundred feet and are then cut off by new crossways and new rooms started, and so on.

Method of Wall Packing and Pillar Making.

The methods of wall-packing or "gobbing" vary considerably according to the varying conditions of roof and floor. The miner is expected to keep the roof well supported in the particular room in which he works. As a general rule he receives no extra pay for so doing, but in case props are used for support they are furnished by the mine operators. When the roof is fairly strong and firm, the larger pieces of the waste are built into walls at intervals of from six to ten feet apart, the distance between these walls varying with the strength of the roof and the amount of material available for such purposes. The waste

material is banked up between the walls, thus forming the "packed wall" or "gob." Plate XXXV. In those mines where the roof is rather weak props are almost always employed. In some cases the props are put in permanently, no attempt being made to remove them as the face of the coal advances, they being surrounded and covered up by the "gob," while elsewhere they are used simply for temporary support and are removed and advanced with the face of the coal, thus saving the expense of new props. Only occasionally is one broken in removing, or, in still rarer cases, by the pressure of the superincumbent strata. When the props are removed the weight of the roof is ultimately borne by the "packed wall" which is often compressed from a thickness of 24 inches to a solid layer only 4 inches in thickness. Plate XXXV.

The entries must also be walled up as the packing wall advances. The wall on each side of the entry is built by the miner operating the room opening on that entry. The miner seldom receives extra pay for this work, but in most cases he prefers to build the entry wall if he can mine near the hauling way, rather than have no wall to build and yet haul his coal by hand fifty to a hundred feet to an entry.

Method of Mining Coal.

The problem before the miner is how to remove the coal from its position between two hard strata, the roof and floor, with as little waste and breakage as possible. The particular condition of the coal stratum with accompanying strata are the essential elements which govern the method employed. When the coal is underlaid with fire clay it is undermined by removing the clay to a depth of 18 to 24 inches and forward from under the coal to two or three feet, thus leaving a portion of the coal stratum projecting into the cleared space, where the miner works, without any support except the tensile strength of the coal itself. This projecting mass of coal in course of time falls, partly from its own weight and partly from a slightly downward movement of the superincumbent strata. By driving a wedge between the roof and the upper surface of coal it may bé soon forced down.

Portions of coal, the full thickness of the stratum, three feet wide and from sixteen to twenty feet in length, are often forced down by a few strokes upon a well directed wedge.

Where the floor is too hard to be removed by the ordinary methods, the cutting is done in the lower portion of the coal stratum. It would be preferable in such case if the roof was not too hard to do the cutting in the roof, prying, blasting, or even wedging up the coal. No coal would be wasted, at least, if such a method were adopted, the waste being the objection to cutting into the coal itself. Machine cutters are used quite successfully when the underlying stratum is fire clay. Mining machines are used at Leavenworth and Atchison and also in the southern coal fields of the state in similar operations under the room and pillar system. It has been noticed that when the coal is removed up even with the clay underlying the coal, and allowed to stand in this way for some hours, the outer six inches of the clay becomes excessively hard, making the cutting out exceedingly difficult. This is obviated by leaving a portion of the coal stratum projecting into the working space, which acts similarly to a bracket, distributing the pressure exerted from above more evenly throughout the coal and underlying strata.

Method of Opening Entries or Driveways.

As the long wall system of mining is employed only in comparatively thin beds the necessity of making the hight of the entries considerably greater than the thickness of the coal stratum in order that men and mules may travel along it is quite evident. Plate XXXV. When the roof material is very hard and the expense of cutting or blasting down is too great, the channel is cut downwards into the floor. This method is employed only where the roof is very hard. When the roof material is soft enough to work by either cutting or blasting the entry is raised to its proper hight by "brushing" down the roof.

The single entries are about five feet wide at the base and four feet at the top, and average five and a half to six feet in hight. In the Osage City mines the hight of the entries is seldom over

four feet and they are correspondingly narrow—from four to four and a half feet. Occasionally the entries are made five feet high and six feet wide. A width of twelve feet is almost always given for double entries. In most mines where all of the hauling as well as mining is done by hand the hight is seldom above four feet.

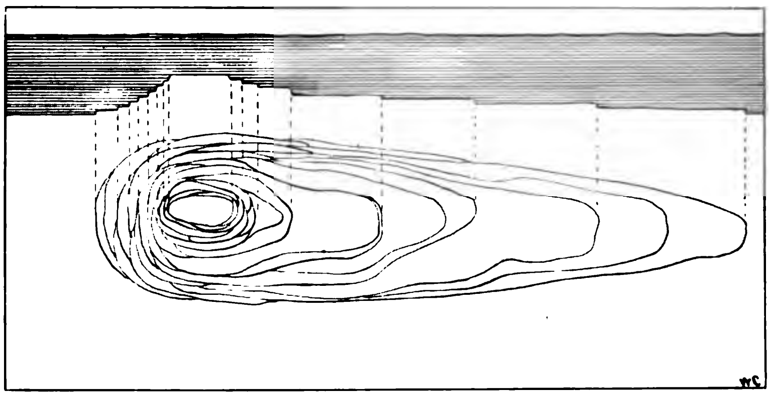


FIGURE 39. A Vertical Section and Horizontal Plan of a "Choke-out" in the Roof of Entry, as seen in Mine at Weir City. This is due to percolating waters loosening the roof, which keeps falling, each succeeding lamina breaking off short of the preceding, thus forming a natural arch.

However, as the roof material constantly exposed to the damp air of the mine rapidly disintegrates and as it softens and loosens will fall, the hight of an entry is thus gradually increased. In places where the pressure of the overlying strata, partially relieved by the removal of the coal, has produced fissures in the roof the percolating waters flow into the mine, loosening the roof material until it falls. This caving-in continues until it finally "chokes itself out," that is forms a natural arch. Figures 39 and 40. By this natural process continually in progress the entries are becoming constantly higher. Another phenomenon noted in the mines, compensating for this hightening process, is the gradual elevation of the floor, known as "creeping." The floor material gradually rises in the entries, yielding to the unbalanced pressure resulting from the opening of the entry. The rapidity of the "creeping" varies with the character of the floor, and is most rapid with clay floors in damp mines.

Uni

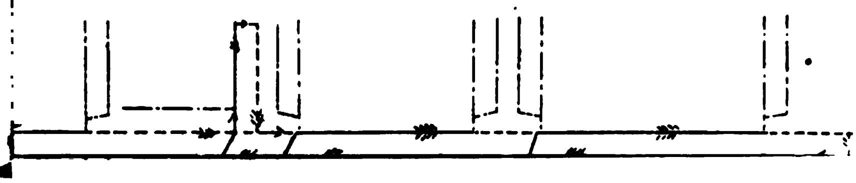
PLAN OF ROOM AND PILLAR SYSTEM OF MINING,

DOUBLE ENTRY METHOD.

By W. R. CRANE.

AFTER F. O. FOGELBERG.

avy lines represent entries, hauling ways, and air passages. The dash and dot rooms, and the dotted lines, air ways. The arrows show the direction of air cur- the system of ventilation.



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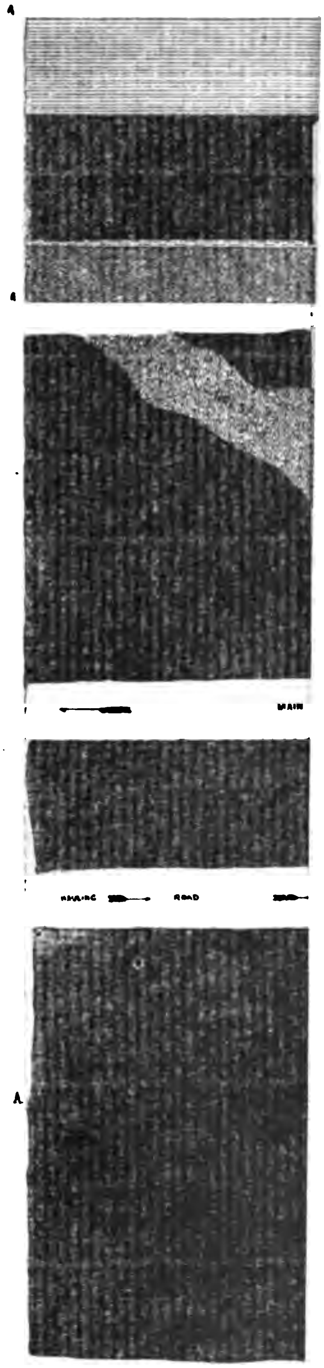

VERTICAL SECTI

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Method of Hauling.

The coal is hauled from the face of the coal to the shaft in cars. The capacity of the car is from 4,000 to 10,000 pounds. In all of the better equipped mines the iron T track is used, but in those mines operated wholly by hand, wooden tracks made from narrow strips of plank or board are employed. The track is laid from the shaft to the face of the coal in the main entries or hauling ways. Leading from the main tracks are branch tracks following the side entries and cross entries to the face of the coal. It will be noticed on entering a mine, conducted on

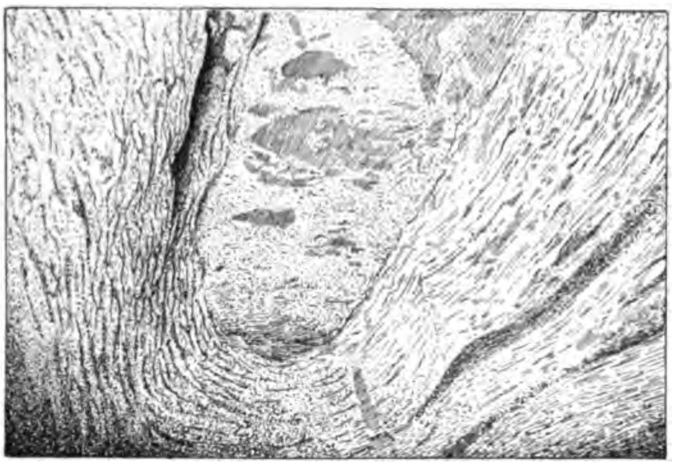

FIGURE 40. A "Choke-out" in Roof of Entry.

the long wall system, that the tracks are in many cases curved inward toward the shaft. This is due to the advancing of the face of the coal, the transfer place not being changed very often, seldom more than once a week. In some mines, cars are run along the face of the coal which is loaded directly into them, while in other cases the coal is hauled to the entry in wooden carriages and in still other instances the coal is "buggied" out. The "buggy" is a wooden platform about two and one-half by three and one-half feet, with two somewhat semicircular runners, so constructed that it may be dragged in either direction without turning around. The coal is placed upon the "buggy"

and dragged to the entry and is there loaded into the car. When the regulation cars are used they are run in on tracks extending from the entry into the room about half way. The branch tracks are connected with the main track at the entry by iron plates which allow adjustment. The inner ends of room tracks are not connected but are left free so that they may be advanced with the face of the coal. In case the cars are run along the face of the coal a "pusher" is commonly employed. The duty of the "pusher" is to keep empty cars ready for the miner to fill, and to remove the loaded cars to the entry where they are transferred to the main track. Empty cars are brought in to replace the loaded ones but, until needed, are removed from the track to allow the passage of the loaded cars. The miners sometimes look after their own cars, loading them and placing them upon the main track, where they are taken in charge by the general hauling crew.

Cost of Mining Operations.

As nearly as can be ascertained the cost of driving an entry is on the average $4.50 to $5 per yard. The average cost of "brushing" down the shale of the roof in the entries is from $1.25 to $1.75 per yard. The cost of removing the coal, or the amount that the miner receives for mining, is from 3 to 5 cents per bushel, 75 cents to $1.25 per net ton; but occasionally only 2½ cents is paid per bushel, 62 cents per ton. These are figures for lump coal; for mine run coal the pay is lower still, ranging from 25 to 40 cents per ton.

THE ROOM AND PILLAR SYSTEM.

The Room and Pillar system of mining is employed in those localities where the coal strata are comparatively thick, ranging from 3 feet upward. Figure 41 and Plates XXXVI and XXXVII. There are two special reasons why the room and pillar system is employed in the thicker coal beds:

First, a large amount of coal is removed, leaving a large vacant space, and with a comparatively small amount of waste. It has been found less expensive and far more practical in thick

coal beds to leave a column of coal standing every few feet, as a natural support to the roof, than to remove it and then introduce material from outside at additional expense.

Second, it so happens that in Kansas the thick coal beds capable of being worked by the room and pillar system lie in a territory where the clay veins, horsebacks, faults, etc., are so abundant.

FIGURE 41. Face of Coal, Room and Pillar System.

There are two methods generally employed in the Room and Pillar system, namely: the Double Entry and Single Entry methods. The double entry is probably the best and is used most extensively.

Double Entry Method.

The shaft is sunk and the "sump" formed as in the long wall system. On the floor of the coal and extending in each direction an entry is driven. The entry is known as the main entry and is the axis of the system around which all the other parts are grouped. It is twelve feet wide and five feet high. On each side of the main entry at a distance of about forty-two feet a side entry or way is driven parallel with the main entry. These entries or ways on each side extend even with the ends of the main entry, all three of them being advanced as the coal is exhausted and the mine developed.

The spaces between the main entry and the side entries are used as pillars. On the walls of the side entry, opposite the main entry and pillar, and at intervals of approximately 100 feet, two entries thirty-two feet apart and parallel are driven at right angles with the side entries. These entries extend in straight lines as far as the coal is worked. Cross ways connect them, not at right angles, but making an angle of about sixty degrees. These oblique roadways are located about a hundred feet apart. Between two sets of the double entries, cross entries parallel to the side entries are driven connecting the two inner entries of the double sets. These cross entries are used for hauling and also for air ways and are driven every forty or fifty feet along the double entries.

Along the sides of the double entries opposite the pillars rooms are opened. The rooms are thirty-five feet from center to center, of which twenty-four feet is worked, thus leaving twelve feet for a pillar between the rooms. The rooms are worked 200 feet long.

The side and main entries are connected by double hauling roads, which are extensions of the double entries extending perpendicular to the side entries, but as there are two side entries there are twice as many entries opening on to the main entry as on to the side entries. The double hauling roads connect the main and side entries at an angle of about forty-five degrees, thus throwing the entrances on the main entry end of the

double hauling road several feet in advance of the entrances on the side entry end of the road. To simplify matters and not have too many roads opening into the main entry at the same point, although on opposite sides, the double entries on one of the side entries are set forward one-half the distance between two sets of double entries, thus making the openings of the roadways into the main shaft alternate one side with the other. The hauling roads opening on to the main entry angle toward the shaft.

By a careful study of the figures in connection with the above explanation this method can be readily understood.

Single Entry Method.

In the single entry method there is only one main entry, with no side or secondary entry or entries associated with it. Plate XXXVII. In this method the main entry is generally advanced with the development of the mine, but sometimes is extended at the start to the proposed limits. From both sides of the main entry other entries are driven at right angles. These entries are located along the main entry at regular intervals of a hundred feet, those on one side being advanced or set back about twenty feet. From the sides of the single entries rooms are driven as explained under the double entry method. The cross entries, air passages, etc., are almost identical with the double entry method. The essential differences are that the main entry is without side entries and the single entries connect directly with the main entry and not with the side entries as in the double entry method.

Single and Double Entry Methods Combined.

A combination of the double and single entry methods has some of the advantages of both. Plate XXXVIII. The details of the method are as follows:

In this system only one main entry extends through the mine, with which are connected on each side the double entries and roadways. Along the main entry, on both sides of the shaft, entries are driven twelve feet wide and five feet high which ex-

tend into the coal bed at right angles to the main entry. These side entries are generally about fifty feet from the shaft and are located at regular intervals of a hundred feet along and on both sides of the main entry. The entries on one side of the main entry are set back as seen in Plate XXXVIII, so that there will be plenty of room to connect the side entry track with the main entry track, thus eliminating the possibility of collisions between two trains entering upon the main track entry at the same time. Parallel with the main entry, and from twelve to fourteen feet on each side, other cross entries are driven connecting the side entries, which are at right angles with the main entry. About twenty-five feet from the main entry (on the side entry) a roadway is driven, extending away from the shaft, making an angle of about sixty degrees. This roadway cuts into another side entry which runs parallel with the first mentioned entry and is used in part as an air and hauling way. These two side entries extend side by side through the mine from the main entry, gradually advancing as the mine opens up. The space between these two entries is left as a pillar to support the roof and is from twelve to sixteen feet wide.

On the side of the entry opposite the main entry, rooms are driven thirty-six feet apart, the coal being taken twenty-seven feet wide. Plate XXXIX. The two series of rooms driven from the two entries and in diametrically opposite directions into the same area of coal will ultimately open into each other. A space of from seven to twelve feet is left between the rooms as a pillar. The waste material obtained in the mining operations is used to close up the worked out rooms so as to prevent any alteration in the system of ventilation, which would certainly result if passages were continually opened and not closed. The main, side, and cross entries are used as air passages and hauling ways as the conditions of the mine require.

If an understanding of the arrangement of the various entries and passages and the relation existing between them is obtained for a small portion of the mine, the complete arrangement with the relation of the parts to the whole will very readily be seen on examining Plate XXXVIII.

The location of the air shaft, overcasts, and the general details of the system of ventilation employed in the different systems of mining will be discussed under a separate head.

Methods of Mining in the Room and Pillar System.

Methods of Driving Roadways.

The methods employed in driving entries or roadways do not differ essentially from those in the long wall system. The coal stratum being thicker will not require as much work either in lifting or digging up the floor or in "brushing" down the roof as in the long wall system. The hight required beyond the thickness of the coal is generally attained by removing the loose strata but when, as is occasionally the case, the roof is excessively hard, the fire clay underlying the coal is lifted. The roof being trimmed in the form of an arch is self supporting. The entry is about six feet high and varies from six to twelve and fourteen feet in width.

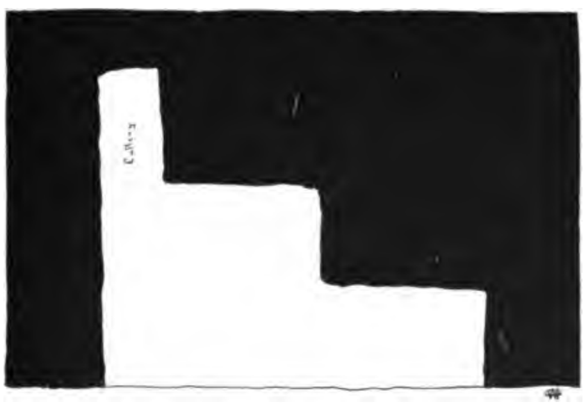

FIGURE 42. Horizontal Plan, showing Method of Opening Entry by "Cutting."

The entry work consists principally in cutting through the coal, "brushing" down the roof, or lifting the floor, and laying the track. The coal is removed from the entry by a system of cutting similar to the method employed in removing the coal in the room. The direction which the miner wishes to take being known, he begins cutting through the coal on one side of the

proposed entry. A space is cut the thickness of the coal, about two feet wide and three feet into the coal. This space is called a "cutting." Figures 42, 43, 44, and 45. The length of time required in making a "cutting" depends upon the character of the coal and whether there are any "horsebacks" intersecting the coal stratum. To make a good clean "cutting" generally takes a day. A drill hole is then made at the other side of the proposed entry. A charge of powder introduced into the drill hole will, when fired, find room to loosen the coal lying between

FIGURE 43. Horizontal Plan, showing Method of Opening Entry by "Cutting."

the drill hole and cutting, and thus by a successive repetition of cutting and blasting the entry is advanced. When a "horseback" crosses the proposed line of entry it must be cut through or passed around. The miner is paid $1.50 per foot for cutting through "horsebacks." If the angle made by the crossing of a "horseback" and an entry is very small the direction of the entry is changed so that it will pass along side of the "horseback," thus utilizing the "horseback" as a pillar. It will therefore be seen that if a large number of "horsebacks" are met with in the development of a mine, the cost of development, on straight lines, will be rather high; on the other hand if the entries are made to conform with the direction of the "horsebacks" a very irregular, unsymmetrical mine will be the result.

OLD STRIP PIT, PITTSBURG.

(Photographed by Crane, 1897.)

STRIP PIT MINING, SCAMMON.

(Photographed by Crane, 1897.)

DRIFT-SLOPE MINE IN CLAY PITS, NESCH BRICK YARDS, PITTSBURG.

(Photographed by Crane, 1897.)

Method of Mining the Coal.

On the side and at right angles with the entry the room is driven or opened. There are several methods employed in loosening and removing the coal from its bed. One method already described in entry driving, is probably the one most generally employed. Figure 42. Three other methods are also shown in Figures 43, 44, and 45, which differ but little from Figure 42. The principle is the same in all three methods, namely: to make an opening which permits the charge of powder to act, thus loosening up the coal. Powder takes the place almost entirely of hand mining by pick and bar in the thicker coal beds. The drill generally used is a very simple tool and is so arranged that it may be turned upon its horizontal and vertical axes — Figure 46 — thus permitting the miner to drill a hole in several widely different directions, with only one setting of the machine. In dry mines the charge is placed the same as in ordinary blasting, but when the mine is wet the charge is liable to become moist before it is fired, and a "firing barrel" is employed to protect it from the water. The firing barrel is an iron or brass tube varying from eighteen to twenty-four inches in length. The fuse is placed inside the tube and both introduced into the charge. The charge and end of tube are then inclosed in a tight wrapper of oiled paper or some substance impervious to water. The charge is then introduced into the drill hole, tamped, and fired, the fuse being within the iron tube and thus kept from the surrounding moisture.

Cost of Mining.

For mine-run coal, or coal in the rough, the miner receives about 30 cents per ton. When the miners are paid for the lump coal only they receive from 50 to 75 cents per ton. When the miner is paid for the amount of mine-run coal he gets out the tendency is for him to become careless and thus break up the coal, producing too large a per cent. of fine coal. For this reason some operators pay for lump coal only, thus encouraging clean lump mining.

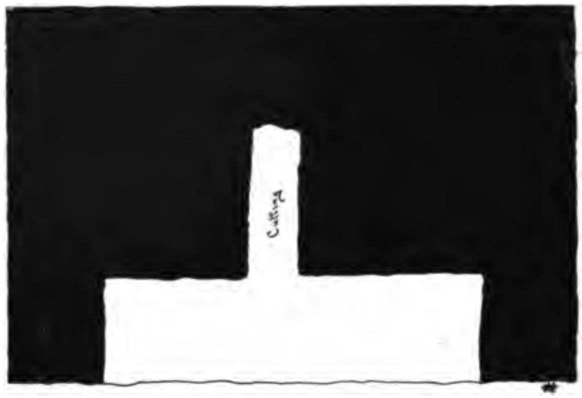

FIGURE 44. Horizontal Plan, showing Method of Opening Entry by "Cutting."

FIGURE 45. Horizontal Plan, showing Method of Opening Entry by "Cutting."

Pillar Building and Gob Packing.

Pillars are not built in the room and pillar system but are simply portions of unmined coal left as supports to the roof. They are generally in the form of rectangles from seven to sixteen feet wide and ranging from fifty to one hundred feet long and are formed by the process of driving entries and working rooms. The waste material is used to "gob" up the entrances to rooms and fill up old rooms.

Method of Hauling.

All of the entries and hauling ways in use have a system of railways operated by either mules, electric power, or steam power. Mules are used the most. The room tracks are connected with the entry tracks by iron plates upon which the cars are transferred from one track to the other. The room track is built into the room and extends up to the face of the coal, additions being made to it as the face of the coal advances, thus keeping the car in easy reach of the miner. The miner loads the cars and pushes them into the entry where they are transferred on to the empty track. From the entries the loaded cars are hauled to the foot of the shaft by mules — one mule hauling from six to twelve cars in a train. Switches are located along the main entry generally at the road head. Here empty cars are kept in readiness to be passed into the mine and loaded ones can pass each other and empty cars on the way to the rooms. Turn outs are also provided in some mines, where cars going both ways may pass.

STRIP PIT METHOD.

Strip pits are employed only where the coal is quite close to the surface. Plate XL. The character of the material lying above the coal regulates to some extent the depth at which stripping may or may not be a paying operation. If the roof material of the coal is a hard rock, as limestone or ironstone, of several feet thickness, the expense of removing this material is generally too great to warrant mining in this way. Unfavorable conditions similar to these are found at Fort Scott, although the coal is stripped there in seemingly paying quantities.

In the southeastern part of the state, on or near the outcrop of the main coal strata, where the coal comes close to the surface, and the covering is generally shale or sandstone, it can be stripped at very little expense. From Cherokee county northward to Linn county the stripping of the roof material is accomplished at a cost of about eight cents per cubic yard. The average paying depth of stripping is about ten feet, although in extreme cases as much as twenty or twenty-two feet have

been removed. The coal from the strip pits is placed upon the market in direct competition with the mine-run coal, and yet fair wages are made by the strip pit operators. One acre of land bearing a coal stratum of 3 feet 6 inches in thickness yields 4,375 tons of coal. A price of $1.25 per ton would give to the land a value of $5,468.75. If a profit of 15 cents per ton is allowed the profit from an acre of such land is $656.25, and from forty acres, $26,240. The large extent to which the strip pit method has been employed shows plainly the profitableness of coal mining when the coal lies near enough the surface to allow of stripping.

The Method in Detail.

The method of stripping is very simple indeed. Lots generally located on the bank of a creek or run, varying from forty-five to a hundred feet in width and from 200 to 400 feet in length are marked out. Scrapers are then employed to remove the material overlying the coal which material is thrown into the creek or hauled out of the pit by roads leading out of the pit ends which are left sloping. Plate XLI. When all of the dirt and rock has been removed the coal is cut through, blasted out, and broken up and then hauled by wagons to the market. The coal mined in this way ought to be cleaner and less pyritiferous (sulphurous) than the mine-run coal as a better opportunity is given to remove the impurities. When the coal has all been removed a new lot is marked off and the denuding process again begun. The material removed is dumped into the pit from which the coal has just been taken, and thus the process is continued until the coal stratum retreats to such a depth from the surface as to render stripping too expensive. At this point drifting is employed, the entries being driven into the banks of the strip pits. Plate XLII. The coal is worked in the entries as has been explained in one or the other of the two systems of mining above described.

MINING MACHINERY.

The advance in coal mining machinery has kept pace with the improvements in machinery for other lines of work. This progress is due to the increased demand for coal and the consequent advancement of coal mining industries in both new and old fields. With the increase in the demand for mining machinery there has been a corresponding increase in the number of manufacturers of it. A list of the more important manufacturers, who are represented by machinery used in the Kansas coal mines, is included in the tabulated data of the principal coal mines of Kansas. Table XII. It is impossible to discuss here in detail the machinery and its adaptation even to all of the more important mines, but a general description will be given of the machinery, with a more detailed discussion of the construction and operation of the typical forms.

Mining machinery may be divided into two classes, namely: First, pit machinery; second, top machinery.

Under pit machinery may be considered: First, mining machinery proper; second, drilling machinery; third, machinery for transferring coal from the face of the coal to the foot of the shaft—hauling machinery; and fourth, the system of signaling employed between the "top" and the "pit."

Top machinery consists of: First, the hoisting apparatus, including the self-dump, scales, and other mechanisms for weighing; second, the coal sorting machinery; third, pumping machinery; and fourth, ventilating machinery.

PIT MACHINERY.

Mining.

For several reasons mining machines have not been very successful and therefore have not met with very much favor in the coal mines of the state; one of which reasons is that the coal strata, except in the extreme southeastern part of the state,

and at Leavenworth, are too thin for the employment of mining machines to much advantage. The irregularities of the floor and the occurrence of "horsebacks," "bells," etc., present great obstacles to the successful operation of such machinery. It may however be said, to the credit of the machines, that if willing operators could be found, the success of coal mining machinery under favorable circumstances, such as are usually found in the Kansas coal fields, would be practically assured. This statement is made in all confidence after having examined the machines and observed them in operation, and after having talked with both mine operators and miners.

The machines are intended simply to undermine the coal, that is, to loosen and remove the underlying clay, the knocking-down and the breaking-up of the coal being accomplished by hand.

The two forms of machines which have been the most successfully operated are the Harrison and Whitman and the Ingersoll, and the John E. Carr patent.

Details of Mining Machinery.

The Harrison and Whitman and the Ingersoll mining machines — Figure 46 — are operated by compressed air conducted into a small engine similar in construction to a steam engine. The machine is not over four feet long and about two feet each in width and hight, and consists of an iron cylinder provided with a piston at the end of which is a chuck into which fits the cutting tool or chisel. The cylinder is mounted upon two wheels, and has at one end and on each side a ring-like handle by which the operator can raise or lower the cylinder and direct the chisel against any desired place. At the top and at one end of the cylinder is a valve for controlling the admission of compressed air at this point, and by this valve the speed and power of the machine are regulated. A plank platform about six feet long and four feet wide is constructed, thus giving a smooth even surface upon which to operate the machine. The ease with which this form of machine may be operated, combined with the small space it occupies, would seem to fulfil all

conditions requisite for a perfect mining machine, and indeed it has been used quite successfully in the extreme southeastern coal fields of the state. The only difference between the Harrison and Whitman machine and the Ingersoll is in the chucks, which can be seen to the best advantage and understood more readily by referring to *a* and *b*, respectively, in Figure 46.

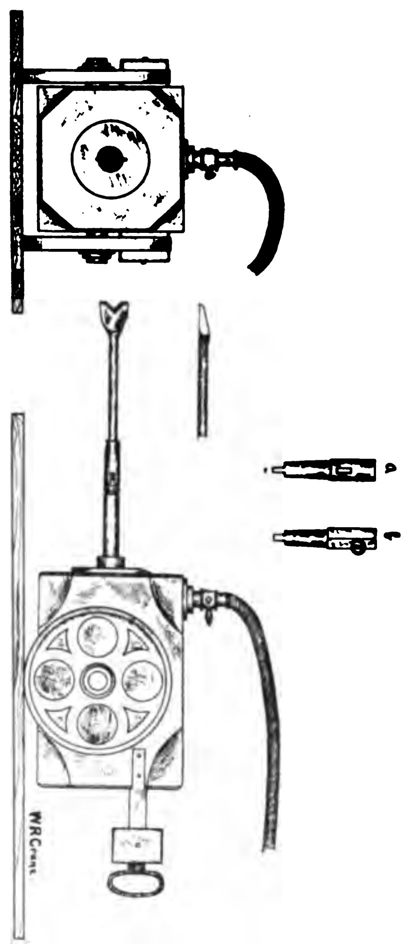

FIGURE 46. The Harrison and Whitman, and the Ingersoll Coal Mining Machines.

Another machine, designed especially for mining under the long wall system, was invented and constructed by John E. Carr, of the Leavenworth Coal Company, Leavenworth—Plate XLIII. This machine has an iron framework about eight feet long and from three to three and one-half feet wide, the main body of which is the field-magnet of a motor. It is operated by electricity. The cutting tools are inserted on the edge of a rotating, horizontal disc, fastened at one side of the machine proper, so that at least one-half of the rotating wheel projects beneath the coal. The armature revolves in a horizontal plane, lengthwise of the machine. On one end is fixed a drum, which rotates in a horizontal plane also, but at right angles to the armature. Upon this drum an iron cable or rope is slowly wound by means of a ratchet wheel, worked by a combination of cog-wheels attached to the armature. The rotating, tool-

bearing disc is geared to the armature of the motor. The frame which supports the disc is so attached to the main frame that by turning a hand wheel, connected with the disc-support by a lever, the disc may be tipped at various angles with the horizontal. Of necessity this angle must be small, as will be seen on examining Plates XLIII and XLIV. This machine is so constructed as to move upon a single rail or track, thus raising the cutting disc off the ground. It does excellent work, is simple, yet strong and efficient. The machines as formerly built were found to be too high for efficient and successful operation in the Leavenworth mines. In thicker coal this machine would undoubtedly be a great success.

A third form of coal mining machine consists of a shaft five or six feet in length, supported in an horizontal position by two arms, the shaft being armed with cutting tools arranged in four rows. In operation the shaft is rotated and pressed against the clay underlying the coal and rapidly loosens it. This cutting tool can be projected into the wall five or six feet.

All the above machines have been operated both in the Leavenworth mines and in the thicker coal beds to the south, and also, to a limited extent, at Atchison.

Drilling Machinery.

A large number of different forms of drilling machines have been devised to meet the various conditions of the different formations found associated with coal strata. An instrument to be fairly successful should have a tolerably wide range of adaptability,—the wider the range the greater the chance it has for being universally used.

Detailed Description of a Drilling Machine.

There is one form of drill which is employed generally throughout the coal mines of the state. It is very simple, yet strong and easily operated, and is easily adjusted to almost any angle, in any plane within the 180 degrees vertical or horizontal arc. It may be operated by one person and is easily taken down and set up. The weight complete is in the neighborhood of thirty pounds.

THE CARR ELECTRIC COAL MINING MACHINE,

Showing Cutting Wheel.

THE CARR ELECTRIC COAL MINING MACHINE,

Front view, showing Winding Reel for Cable.

On consulting Figure 47, the following description will be rendered much plainer. Two side bars, *AA*, of wrought iron, and notched as seen per cut, are bolted to two end castings, *BB'*. One of these castings, *B'*, is provided with an extensible leg, the other, *B*, with coarse pitch screw threads, *C*, arranged with a sliding rod, *D*, by means of which it may be run back and forth by hand. Both ends are formed into sharp points which are forced into the roof or side walls and thus prevent the drill frame from slipping. A block, *E*, terminating in two rod like arms which fit into the notches on *A*, thus allowing a rocking or vertical movement of the drill proper, is made into two separate parts, each part bearing one-half of the threads in which the rod bearing the drill works. The other parts of this block are held together by pins, *F* and *F'*, thus holding the two pieces firmly together and forming a wide cap which allows but little play of the drill rod. This drill rod is from two and one-half to three feet in length and is furnished with threads for very nearly its whole length. On one end of the rod is a rectangular socket, *H*, a receptacle for the drill blade, *I*, the outer end being squared up upon which a crank, *J*, fits. Several openings are made in the crank to fit upon the square end of the drill rod to allow of more or less purchase or speed being given to the drill as the formation to be drilled is hard or soft. The drill blade is a flat steel bar twisted into a spiral or auger-shaped blade, terminating on one end in a semi-circular cutting edge with a "V"-shaped notch in the line of the axis of the blade. The other end of the drill blade is made to fit into the above mentioned rectangular receptacle of the drill rod. The whole mounted and presented sideways and again as it is seen at end is given in Figure 47.

Hauling Machinery.

Track.

The track consists of a T-shaped rail similar to other rolling stock rails, but generally very light. The length of individual rails is immaterial as they are constantly being cut up to adapt the road to new switches and bends, factors which are con-

stantly entering into the economy of mining and in most cases with a great deal of irregularity. At the point where a side track is connected with the main entry track special connections must be arranged, especially when the track is to be changed every few days. Generally an iron plate is placed directly under and bolted to the main and side tracks, the side track being fastened by only one bolt, so that it may be hinged back and forth upon the bolt as a pivot, the plate thus forming a firm, even surface for the rail to move upon, besides acting

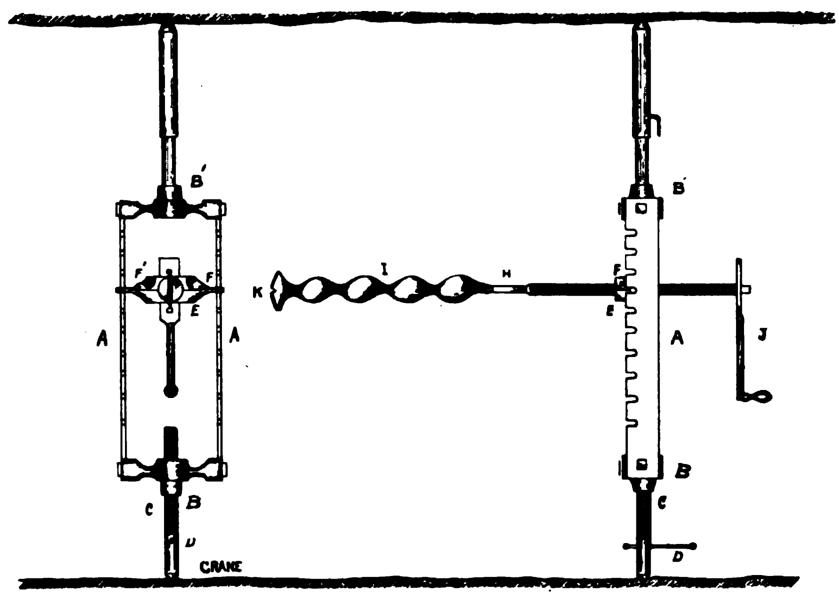

FIGURE 47. Miner's Drill, as Used Principally in the Crawford and Cherokee County Mines.

as a transfer plate upon which to shift the cars from one track to the other. The rails are spiked to evenly hewn hard wood sticks, or in some cases pieces of sawed timber. The distance between the rails is from two to three feet, more generally above than exactly two feet. When it is possible the track is leveled, but in most cases this is impossible, so that a smooth track is the only condition actually sought.

Cars.

The cars used for hauling coal are from four to five feet long and from two and one-half to three feet in width, on the bottom. The floor of the body proper, to which the axles are attached, and also the two sides which rise at right angles to the bottom, are made of hardwood boards bound together with heavy straps of iron. The sides are held to the bottom by the same straps of iron that hold the bottom planks together and are vertical at the bottom, and flaring at the top to increase their capacity and facilitate their unloading. In most cases doors are so hinged to the cars that when the car is to be unloaded the door is raised automatically and the coal is free to slide out. Figure 48. In other cars no doors are used, the larger blocks of coal being placed in the form of a wall across the end

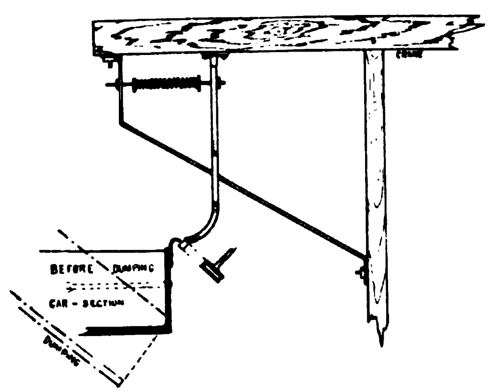

FIGURE 48. Automatic Car Door Opener.

of the car and the finer coal filled in between. The two sets of wheels are close together to facilitate the dumping of the cars. Couplings, consisting of an iron loop or eye, are furnished each end of the car, the ends of two cars being connected together by short chains having a hook at each end. The cars have an average capacity of from 1400 to 1600 pounds each.

Motive Power.

Mule power is used most extensively in the Kansas coal mines, but in a few of the better equipped mines steam and electricity are employed. Mules, when well fed and properly handled, make very handy and efficient power, but the expense and trouble of keeping them about the mines is so great that, in the larger mines, it is only a question of time when they will be wholly replaced by steam power.

Steam and electric hauling, when properly employed, have many points of advantage, namely: a saving of time, less labor and expense for the power obtained, and greater convenience. The cable drum, run by either electric motor or steam engine, is generally located at a point near the foot of the shaft. The steel or iron cable is wrapped several times around the drum to prevent slipping, Near the drum is a tension carriage to keep the cable taut. Sheaves are placed at both ends of the system and at the bends, while small rollers are located every few feet along the track and midway between the rails—these keep the cable approximately in the middle of the road. The sheave at the extreme end of the system is from six to eight feet in diameter to start the cable on the return track, which latter is provided with a system of sheaves and rollers as found on the advance track, to guide the cable to the driving drum. In some mines two or more systems are operated, often side by side. The driving drum is connected directly with the engine or motor by means of a system of geared wheels. Mortised wood gears are generally employed to deaden the noise as much as possible. A system of grips is employed by means of which the operator can connect or disconnect at will a car with the moving cable. A pilot car is often employed to which a train of cars is coupled. This pilot car is not used for hauling coal, having simply a seat, a lamp, and two grip levers. Latch-switches are used when roads branch off from the main track; which switches are opened and closed to let the cars pass. To go more into detail regarding this system would be unprofitable and impossible as well, in the present report.

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Signaling Apparatus.

The signaling apparatus employed in the mines is, in most cases, extremely simple, consisting of a wire, passing over pulleys when a corner is to be passed, through guides, and reaching from the foot of the shaft to the top or engine house. A lever fastened to the wire at the bottom when drawn down causes a hammer to strike an iron plate or bell, thus giving the signal, one or two taps as the case may be. In a few mines the tube transmitter is used, while in still rarer instances telephones are employed. In the shallow mines the voice is relied upon almost entirely for communication.

TOP MACHINERY.

Hoisting Apparatus.

The hoisting apparatus of a mine consists of: First, the shaft which guides the cages in the upward and downward passage; second, the cages and the cables which lift them; third, the drum upon which the cable is wound in the act of elevating and from which it is unwound in the act of lowering the cages with the loaded and unloaded cars; and fourth, the engine which furnishes the power requisite for raising the cages. All other parts are secondary to the above mentioned ones and will be considered in connection with the particular part of the hoisting apparatus proper with which they are most closely associated.

Towers.

There seems to be no special standard for the construction of towers. The elevator part of the tower is but a continuation of the underground shaft timbers, and rises to a hight of fifty to one hundred feet. It is composed — Plate XLV — of four corner timbers which are braced by timbers passing to and firmly mortised in the adjacent corner timbers. The method of bracing differs considerably in towers made by different contractors, but the most common way is to brace straight across, thus making a square frame every twelve feet. On two opposite sides an extra timber running parallel to the corners and exactly half

way between them is bolted to the brace timbers. These are guides upon which the cages slide and are, in fact, the only point on the tower or shaft timbers which the cages touch. Figure 49. The lower part of the tower is built of 8 by 8 inch, or 8 by 10 inch timbers, being mortised together and raised as one piece. Upon these timbers is built the top house which protects the operators from the weather, keeps the machinery dry, and furnishes a covering for the chute which is built in and firmly fastened to the lower timbers of the tower. The upper end of the chute opens into the top house. Above and topping the shaft timbers is a framework, a continuation of the shaft timbers, supporting the two sheaves which guide the cables from the tower house down the center of the shaft. To one side is built the scale and weighing room. Cables or wooden braces keep the tower from rocking backwards and forwards when a load is being raised or lowered, and are on the sides or ends, depending upon the direction that the engine or power house is located from the tower. Stairs fastened to the timbers of the tower are built from the ground to the floor of the top house.

In the "jigger" or "shaker" tower — Plate XLV — the chute is swung on iron bars, *RR*, the whole being shaken back and forth by an engine, E', situated near the shaft. The tower built on this plan must needs be much more solidly built than the ordinary parallel-bar screen chutes. Even when bolted and braced in every possible way the whole tower shakes and sways when the heavy chute is jerked back and forth. The parallel bars, K', K'', K''', or perforated plates, are arranged practically the same in the jigger towers as in the stationary, with the exception that in the jigger tower the screens are arranged in steps as the chute descends. By this arrangement the coal is more thoroughly screened and is moved off the screen more rapidly.

Cages.

The elevator carriages or cages used in the shaft consist of a framework of timbers and iron rods, having a top and bottom.

The cage is a rectangular shaped framework, $BCB'C'$, in vertical section, and $PPPP$ in horizontal section — Figure 50 —

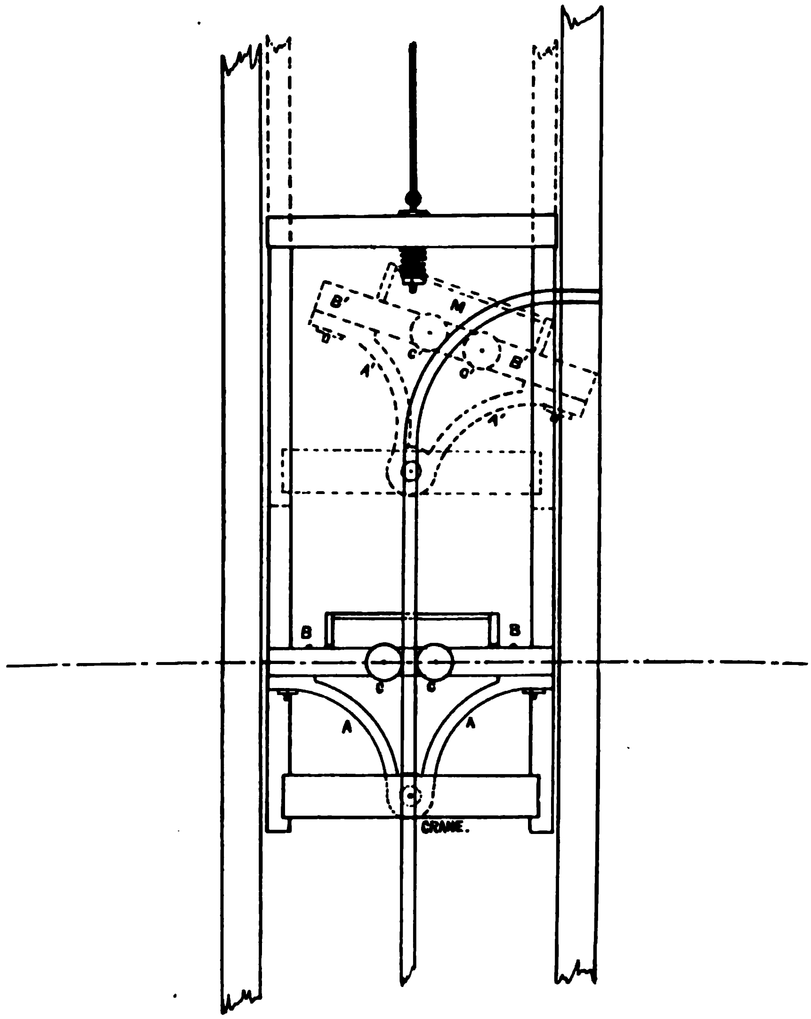


FIGURE 49. Section of Elevator Shaft, showing Cage Ascending the Shaft. The dotted lines show the Bennett Automatic Dump in Operation.

sliding up and down in the square or rectangular space formed by the shaft timbers, *A*, and guided by the guiding cleats, *LL'*. The floor, *P P P P*, is made of heavy hard wood plank well bolted together. At the corners, *P P P P*, hard wood timbers, *BB'*, and *CC'*, are fastened and connect the roof with the floor.

In a good many frames these corner timbers, *BB'* and *CC'*, are iron rods. In those cages not constructed for automatic dumping there is only one bottom, but in the self-dumping cages there are really two bottoms; the lower and true bottom of the cage, usually not floored over; and the upper and false bottom, which is planked, and upon this floor is laid the track upon which the cars stand while the cage is being raised or lowered. The false bottom is so arranged as to be tipped forward at an angle sufficient to allow the coal to slide from the car. Figures 49 and 50.

Between the rails of the track is a combination of levers,

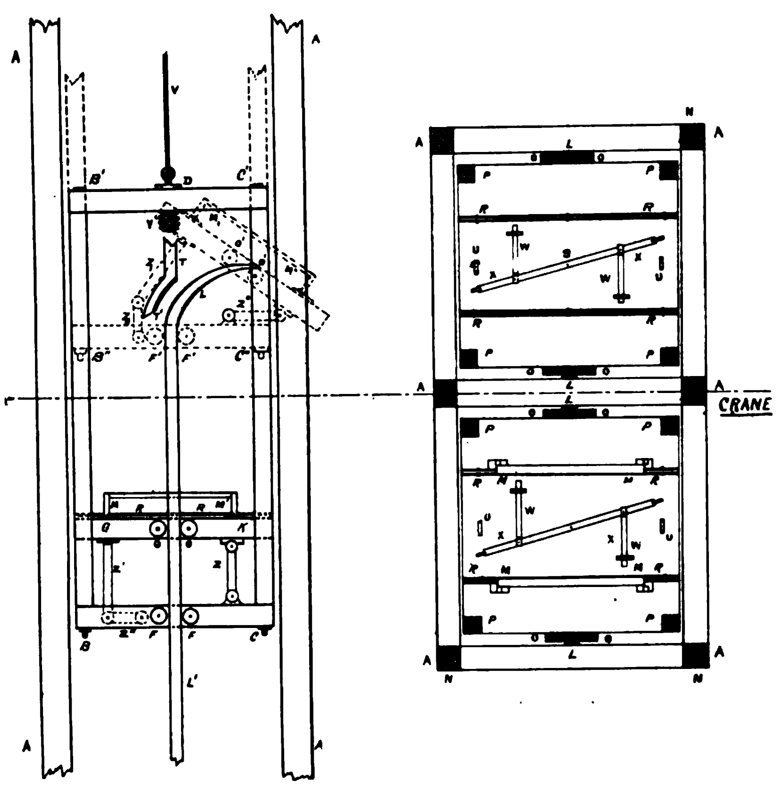
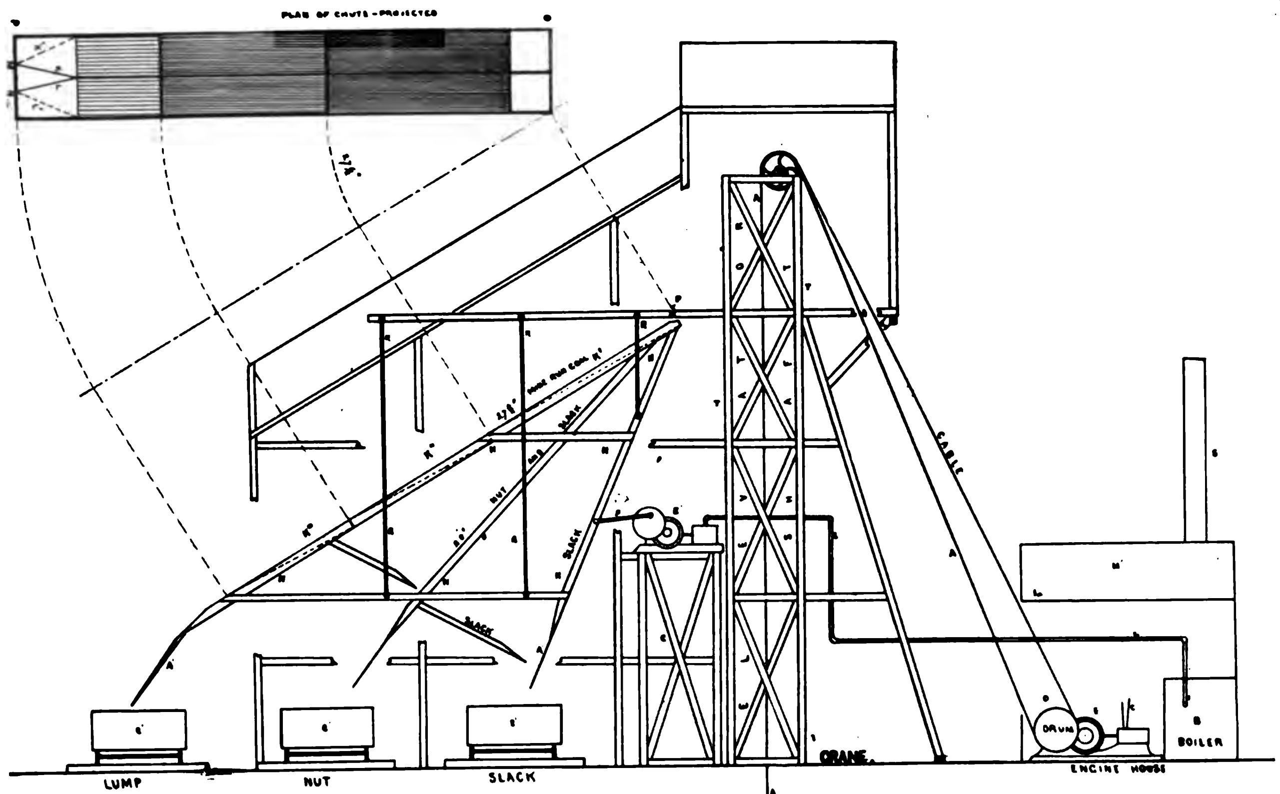
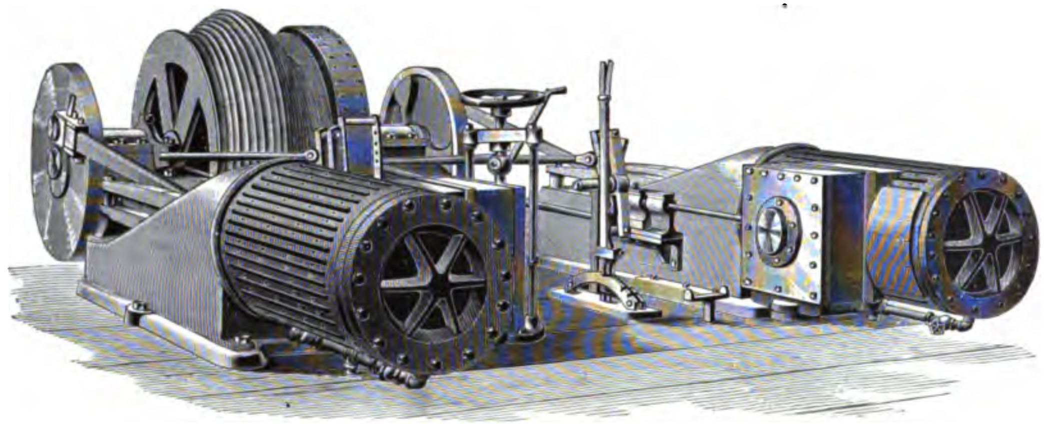


FIGURE 50. Section of Elevator Shaft, showing the Hamilton Automatic Dump. The figure to the left shows the Hamilton Dump as attached to the cage. The dotted lines show how the dump works. The figure to the right shows a section through the shaft, bringing to view the floor of cages, with track, guards, and dogs.



TOP WORKS OF TYPICAL SHAKER SHAFT.



THE CRAWFORD AND McCRIMMON DOUBLE HOISTING ENGINE.

called a dog, $W X$, Figure 50, which, when pushed to one side, permit the car to be rolled upon the track, and when pushed back again hold the car from running off. Rollers, FF, fastened to the top and bottom of the cage and to the false bottom in the automatic dumping attachment, rest on each side of the guiding timbers, $L L'$, and thus hold the cage in place. The rollers attached to the false bottom and situated on each side of the guiding timbers cause this bottom to be elevated and tipped when brought in contact with the curve in the upper part of guides, $L L'$.

The roof of a cage has a framework of timbers, through the central one of which a bolt, D, passes, which bolt passes through a coiled spring, Y, and is then furnished with washer and cap. The head end of this bolt is formed into an eye into which the wire cable, V, is fastened. Figures 49 and 50. This arrangement prevents any sudden or violent jerk or jar being severely felt in the cage. Upon the upper framework is generally fastened a stout iron shield to prevent rocks or coal from falling into the cage.

The guards, $M M$ and $M' M'$, Figure 50, fit loosely above the wheels of the car while upon the track, so that when the cage is tipped forward the car cannot be thrown from the track. In Figure 50 these guards are shown in the lower drawing of the horizontal section of the cage floor, but not in the upper drawing.

Cables.

The cables to support the cages with accompanying load are usually from one to one and one-fourth inches in diameter, although in some of the smaller mines, especially horse-power shafts, three-fourths inch cable is used. The cable is a steel rope, the separate parts of which are malleable steel wires twisted into strands, which in turn are twisted into the main rope. These cables are very durable, having a life of from four to six years and even longer, if care is taken regarding the diameter of the sheaves and if they are protected from the saline and acid water usually found associated with all minerals and with coal as well.

Hand Dumping.

As remarked on page 247, the car axles are placed close together, bringing the wheels nearly under the middle of the car, in order to facilitate dumping. The car is pushed from the cage upon a short section of level track leading directly to the chute. At the end of the track and at the beginning of the chute the rails are fashioned into hooks—see plan of tower, Plates XLV and XLVII. The front car wheels entering these loops are prevented from moving onward, whereupon a downward pressure on the front end of the car or a corresponding lift on the back of the car causes it to swing upon the axle of the wheels in the loops, and thus is tipped forward at an angle of about forty-five degrees with the track. In the act of dumping, an arm, as shown in Figure 48, catches into a loop on the gate in the front end of the car and raising the gate allows the coal to slide freely out.

Automatic Dumping.

In some of the better equipped mines automatic dumping machinery is employed. In the automatic dumping arrangement the car is not taken from the cage, thus necessitating a closer approach of the chute to the shaft. As explained under the head of "Cages," page 252, the track and dogs on the cage floor and the guards above the car wheels keep the car from rolling off or sliding about during the hoisting and dumping, and hold it firmly upon the cage. The door of the car is opened as in the process of dumping by hand. The actual mechanism which tips the car is attached to the bottom or floor of the cage. Most of the automatic dumps have been designed by the owners or operators of the mines. Those in most common use are, the Hamilton, the Bennett, and the Griffith.

The Hamilton automatic dump consists of an arm, *Z*, and elbow, *Z′ Z″*, and two rollers, *O O*, Figure 50. The platform, *GK*, when level is supported by the arm *Z*, which stands in a vertical position, and by the arms *Z′* and *Z″*, which form the elbow of the joint, *Z′ Z″*, the arm *Z′* standing vertically while *Z″* is in a horizontal positon. The guiding timbers, *L L,′* are furnished with a curve at the top which bends in the direction

that the coal is to be dumped. The guiding rollers, *O O*, disposed on each side of the above mentioned timbers, cause the cage floor to be tipped forward when the curve just referred to is reached as the cage ascends the elevator shaft. The vertical arm now becomes horizontal, while the vertical and horizontal arms of the elbow joint make an angle of forty-five and ninety degrees, respectively, with the horizontal. The cage floor is given a tip of nearly forty-five degrees with the horizontal, thus removing the danger of falling coal during the act of dumping. In Figures 49 and 50 that part of the figures in solid lines shows the cage and floor in position for hoisting, the dotted lines show the cage in the act of dumping.

The Bennett automatic dump is much simpler than the Hamilton, consisting of two heavy iron brackets, *A*, hinged upon a shaft attached to the lower timbers of the cage, the floor, *B*, being bolted to the top of these brackets. The rollers, *C*, Figure 49, fastened to the floor of the cage cause it to be tilted forward when the curve, *M*, in the guiding timber is reached in the ascent. The edge of the floor of the cage is, in this form, also projected beyond the shaft, thus insuring against any coal falling down the shaft while dumping. The Griffith's automatic dump differs from the Bennett only in the guiding arrangement. Instead of having the guiding timbers, upon which the cage slides, curved at the top, they continue straight to the top of the elevator shaft. A projecting arm or block fastened to the floor of the cage comes in contact with a block fastened to the shaft timbers, this holds back the front edge of the cage floor while the back edge or side rises as the cage is elevated, thus tipping the floor to the required slant.

The automatic dump takes the place of two men to every cage and is a great saving in time as well as labor. The only serious objection raised to its use is the breaking up of the coal, due to the force with which it is thrown into and down the chute from the car.

Hoisting Engines.

The hoisting apparatus consists: First, of one or two steam engines — the number depending, as a general rule, upon the ca-

pacity of the plant; second, of a drum upon which the cable is wound; and third, of the mechanism for regulating the speed and direction of the rotation of the drum. The drum may be single or double and is generally cylindrical, but where deep mining is necessary conical drums are used. Conical drums have not as yet been employed to our knowledge, in the Kansas coal mines. When the elevator shaft is single one end of the cable is attached to the drum, the other to the cage. When the shaft is double the cable is wrapped six or more times about the drum, each end being attached to a cage. By this method when one cage is elevated the other is lowered. This necessitates a reversing apparatus so that the cage may be run right handed for a time, then reversed and run left handed, thus raising and lowering the cages in turn. The reverse mechanism is simple and is the same as that used in the locomotive and other engines where a reverse rotation is desirable. A hand regulated shut-off, for the steam, and a brake for stopping the rotation of the drum, at a certain point, are also necessary. A rotating valve, arranged with a long handle and taking the place of the usual hand-wheel shut-off, is the more common form employed. A friction brake is employed and consists of an iron or steel band passing entirely around one end of the drum. One end of this band is securely fastened to the framework which supports the engine, the other end being attached to a lever operated by foot. A slight pressure upon the lever tightens the band about the drum, thus producing a most efficient form of friction brake.

An excellent form of double hoisting engine, with single or double drums, is manufactured by Messrs. Crawford and McCrimmon, of Brazil, Ind., the drum of which furnishes a new feature in hoisting engines. The following extract is taken from the Twenty-sixth Annual Message, page 8: "Being made conical both ways, and having the bulge in the middle, and grooved from end to end, the rope winds from the small diameter at one end over the large diameter at the middle and thence to the small diameter at the other end. It will be seen that we have the advantage of the small diameter in starting the load easily

and slowly, and also in landing it in the same way, while we have the larger diameter at the middle to make speed. Besides, the slow motion of the engine at starting and landing makes the handling of the load doubly slow and easy at these points, while the speed of the engines may be very rapid through the middle of the run, where the speed of the load is further rapidly increased by the larger diameter of the drum."

Scales.

There are two forms of scales employed about a mine, namely, the "top" and the "track" scales. The top scales are placed at the top of the elevator shaft, the platform of which is a small portion of the track, sufficiently large for a car to stand upon, lying between the shaft and the chute. The cars are run from the cage upon this track, are weighed, then run forward and dumped into the chute. In those shafts where the coal is dumped automatically the above method is not applicable. In such cases a weighing cage is occasionally employed and consists of a portion of the chute suspended by the scale bars; an iron door forms the lower side of this cage, which door may be raised and lowered at will. In this cage the coal is dumped and weighed, after which a light pressure upon a lever throws open the door and allows the coal to proceed down the chute. The weighing cage does not appear to be in much favor in the Kansas mines, probably due to the extreme rough usage to which scales thus used must be subjected.

The track scales do not differ in the least from the usual railroad track scales. They are located at the foot of the chute where the car must stand while being loaded. Occasionally they are set in the switch where the cars are run after being loaded. The Fairbanks, Monarch, Howe, and Standard, are the scales most usually found about the Kansas mines, and modifications of which are employed both as top and track scales.

Coal Sorting Machinery.

Chutes.

The chute consists of two long inclined planes, *A* and *B*, each six feet wide and from twenty to forty feet long. Plates XLV and XLVII. The main part of the chute, *AB*, makes an angle of twenty-seven and one-half degrees with the floor of the top house, *CD*, or with the horizontal. The two chutes seen side by side in Plate XLV are separated by an eight or ten inch partition. The upper six feet of the chute is covered with iron plates six feet wide and six feet long. These plates receive the coal directly from the cars. The coal slides from these plates very readily and next passes over a set of parallel bars. In some chutes several screens or sets of parallel bars are employed. Beyond the above mentioned part of the chute the remaining portion makes a smaller angle with the horizontal, generally an angle of about twenty-five degrees. Plate XLVII. This is to break partially the force of the moving coal as it comes from the steeper incline. This portion is also sheathed with iron or steel plates. The partition mentioned above stops from six to eight feet from the end of the chute to make room for a set of partitions or gates, by means of which the coal may be conducted through one opening or through two as the case may require. The gates, *K* and *L*, are swung upon posts, *NM*, fastened into the end of the chute, *OP*, about a third of the distance from each side. These doors or gates reach to the end of the partition just above and from this point may be swung to the outer side of the chute, as seen in Plate XLV, *K'L'*. When it is desirable that the coal be directed into one stream both gates are thrown to the side as *K'L'*; when the coal needs to be scattered the gates are drawn to the partition, as *KL*, thus forcing the coal to pass down the chute into which it was first dumped. At the extreme lower end of the chutes aprons, *A'* and *A*, are hinged so that they may be raised or lowered to any hight, thus furnishing a means of laterally distributing the coal throughout the car. The chute is made of heavy timbers which are fastened to the framework which supports the top house.

They are thus made very strong and durable and are also protected from the weather by the roof of the top house, as will be seen in Plates XLV and XLVII. A directing plane — Plate XLVII — making an angle of thirty-four degrees with the horizontal, catches all of the coal that passes through the parallel bar screens and directs it to another plane, which in turn redirects it into the revolving screen. The mine run coal dumped into the main chute passes over the parallel bars; in this transit all but the coarser lumps fall through. The coal which passes over the bars is therefore "lump" coal; that which falls through is "slack" and "egg" and "nut" all mixed together. In passing through the revolving screen, *DE*, Plate XLVIII, this in turn is separated into slack, egg, or nut, according to its size.

The above described form is only one of the many ways that the screens and directing planes are arranged. Space will not permit of more detailed description of the different forms of chutes.

In the discussion of the towers a short description was given of the shaker shaft and the method of screening therewith.

Screens.

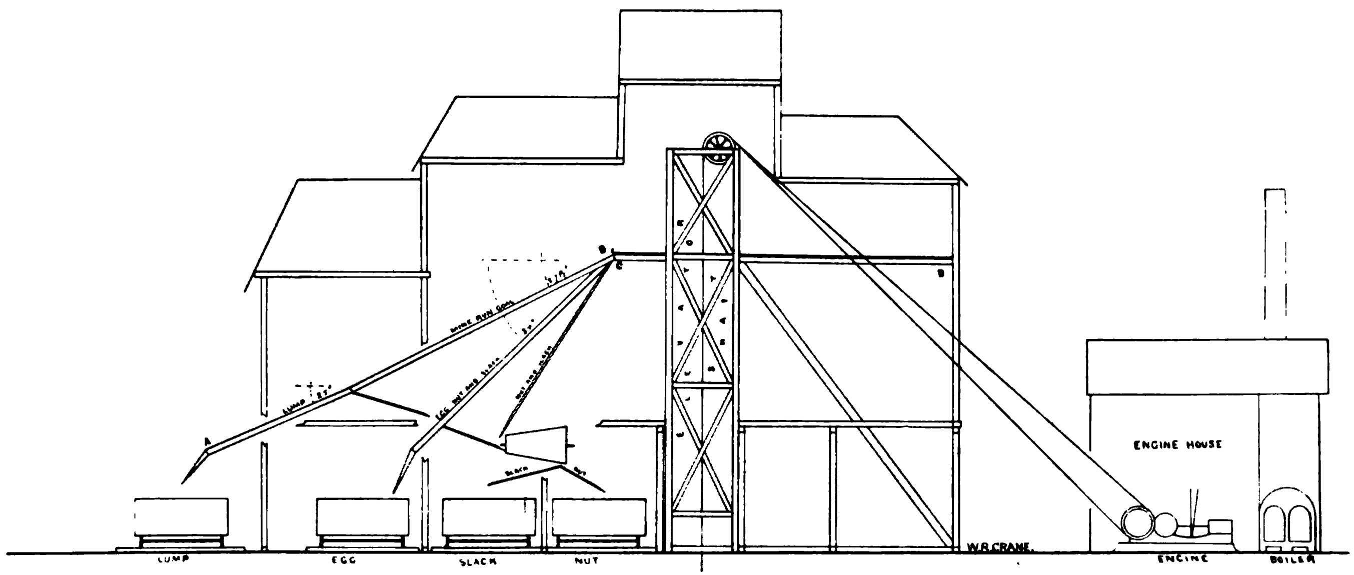
Parallel Bars.—The parallel bar screens used in the chutes are made of iron bars set edgwise and running parallel with the chute. They are often made in sections so that finer or coarser screen may be substituted. In some cases hard wood planks are used which are also placed edgewise and are bolted together in sections. The plank form of parallel bar screen is used more commonly in both the horizontal and slanting coal sorters. The mine run coal is thrown into the horizontal sorter at a point near the shaft, from which point it is carried along by an endless belt drag — that is two chain belts held apart by wood or iron slats which catch the coal and drag it from one set of screens to another, the distance between the bars of the screen increasing as the coal recedes from the shaft. The coal thus passes from the less coarse to the more coarse screens and is thereby sorted into the different grades, as slack, nut, egg, and lump.

Perforated Screens.— Perforated iron plates are often used instead of the parallel bar screens. The perforations are circular in some, square in others. They are also arranged in sections. These screens are not as satisfactory as the parallel-bar form as they present more friction to the coal. For finer coal they are probably better as they do not clog as readily as the parallel forms.

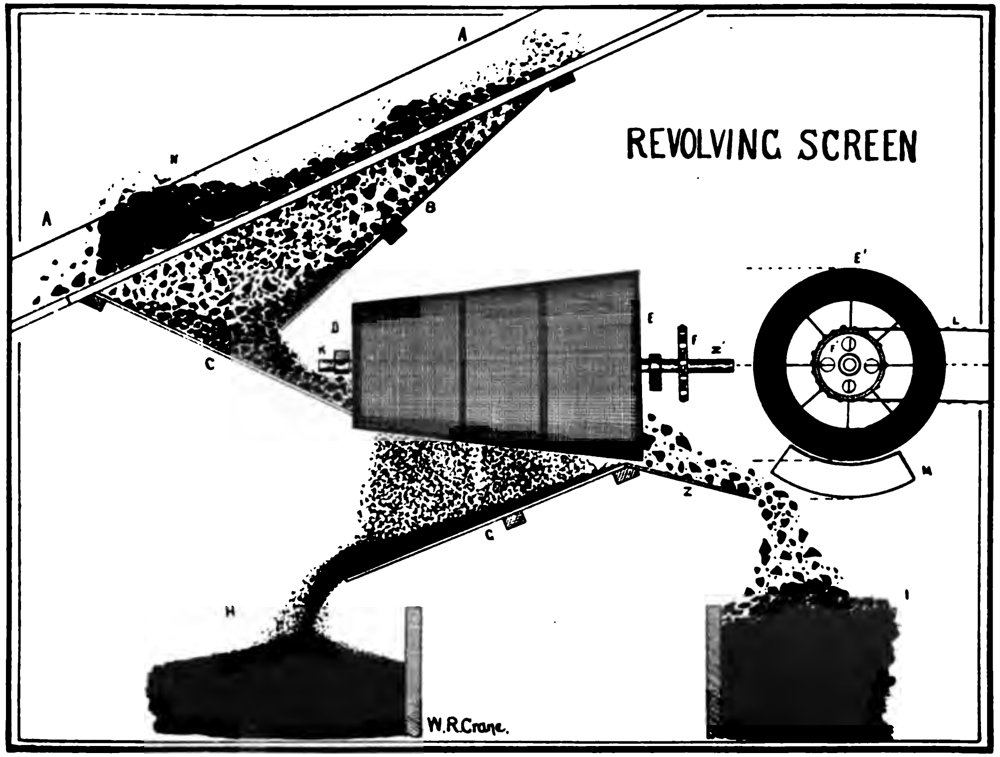
Revolving Screens.— Revolving screens are built in the form of a truncated cone. Figure 52 and Plate XLVIII. They are generally about eight feet long and increase from a diameter of about two feet, at the smaller end, to a diameter of about three feet at the larger end. They consist of iron hoops, placed every eighteen inches to two feet and braced to a shaft which forms the axis of the screen, upon which is fastened a coarse wire netting, *DE*, generally of the same mesh throughout but in rare instances having the size of the mesh increase in passing from the smaller to the larger end. The coal enters the small end and as the screen rotates, the shaft being horizontal, the coal must of necessity pass over a large surface of the screen before emerging from the larger end. An apron, *G*, catches the fine coal which falls through the screen while that which is too coarse to pass through the meshes passes entirely through the screen in the form of nut and egg, is here caught by an apron, *Z*, and conducted into the car. The screen is generally operated by a screen engine — an engine built especially for this work — but is frequently run by tumbling-rod or endless chain belt from the pump engines.

Pumping Machinery.

In those mines where coal is found at no great depth considerable water is generally met with in the mining operations. In such mines the pumps for removing the excess of water are located in the tower proper or in a separate house by themselves, or, in many cases, are placed at the bottom of the shaft not far from the "sump" from which the water is drawn. In exceedingly wet mines sumps are located more or less regularly throughout the mine or at a few well chosen places, at which



TYPICAL PARALLEL SCREEN SHAFT.



REVOLVING SCREEN, SHOWING THE SORTING OF COAL,

As generally used in the Coal Mines of the State.

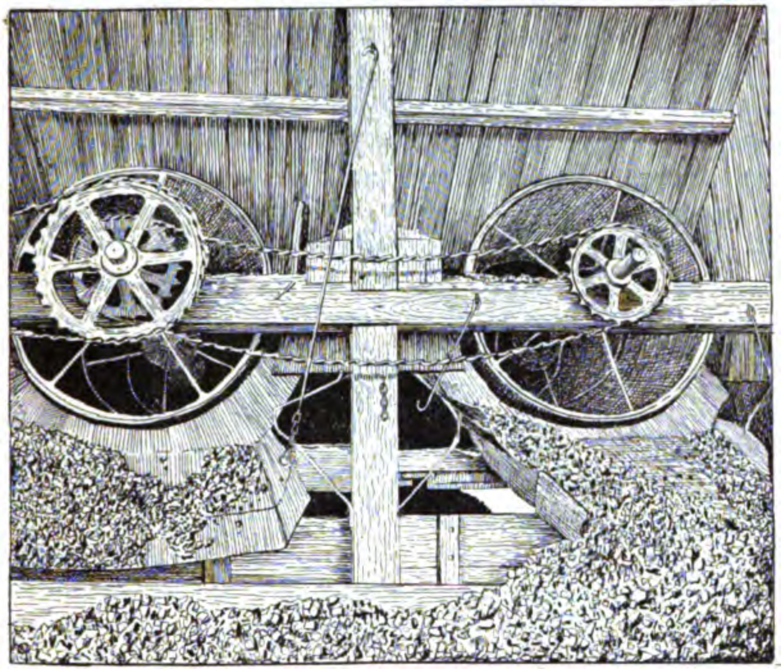


FIGURE 52. Front View of Revolving Screens.

places pumps are placed, thus requiring several pumps to the mine. In mines of any considerable importance steam pumps are most usually employed; in a few instances pumps run by electricity or electric power are used. In the deeper mines electricity is the best and most economical power obtainable, and is used extensively in the Leavenworth mines.

A form of endless belt pump is very common in the shallower mines of the state and also in the strippings. In the mines this form of pump is run by steam power, while in the strip pits horse power is generally employed. The pump as constructed for surface work, as in the strip pits, may be seen in Plate XLIX. The principle, regardless of where used, is the same, so that the strip pit form will be taken as a type of this endless belt pump. The elevator, *AB*, is a long rectangular tube varying from six to twelve inches in width and from three to

four inches in hight, inside measurement. The endless belt, *LM*, passes through this tube. The belt is canvas upon which cleats, *K*, are nailed or riveted every twelve or eighteen inches. There is just enough room for the cleated belt to pass easily through the tube and consequently when run at a high rate of speed a large quantity of water will be carried along with the belt by means of the cleats. At the bottom of the elevator is a foot, *O*, provided with a roller which guides the belt into the lower end of the tube. The framework of the foot prevents any foreign substance from catching in the belt and being drawn into the elevator. The drive wheel, *Z*, is fastened to a square axle, *N*, to which the wheel, *F*, driven by the engine or horse power is attached. The whole arrangement may be readily seen in Plate XLIX. These pumps are used extensively also in the lead and zinc mines in and about Galena and Joplin.

Steam pumps, built especially to resist the action of acid and saline waters, are used very extensively in the better equipped mines. These pumps are also built very strong and durable so as to stand long and hard usage such as mine pumps alone are subjected to.

Ventilating Machinery.

The ventilating currents of air are started and maintained by large fans run by steam power. These fans — Figure 51 — vary in size according to the extent of the mine, but are generally from ten to twenty-five feet in diameter and from three to ten feet in width. The engine which furnishes the power is generally fastened directly to the framework of the fan, the cylinder standing at an angle of forty-five degrees with the vertical and connected directly with the crank wheel of the fan shaft; thus no power is lost in gearing or belting. The arrangement is simple and complete, and as a general rule it receives but little care, running with a head of steam which will give a certain speed, which pressure is maintained by the regulating valve being set at a certain point where it is left from day to day, and even for weeks, an occasional oiling being the only attention necessary.

FIGURE 51. The Crawford and McCrimmon Power Fan for Ventilation Purposes, as Used in Mines about Pittsburg and Weir City.

The house in which the fan is placed is generally an isolated building, built directly over the air shaft, and is therefore situated a few yards from the other buildings. The fan house is built especially to conform to the shape of the fan as much as possible, but is generally rectangular in plan, having straight sides. Plate LI. Upon one side a square funnel-shaped projection is built in which a vertical sliding door is arranged, hung by weighted ropes, so that it may be easily adjusted, thus allowing the opening or closing of the aperture through which the air is drawn in or expelled from the mine, depending upon the intended direction of the air currents. The systems of ventilation will be discussed more in detail under the correlation.

CORRELATION.

From the above descriptions of the various forms of machinery employed in the mine, "pit," and "top," a fairly good idea may be obtained of the machinery actually used. The relation of

one part to another part has not as yet been shown, but that may be brought out by a brief description of the processes through which the coal passes in transit from the face of the working to its ultimate resting place in the flat or box car upon the track.

Mining.—The coal at the face presents a perpendicular wall, capped with shale, sand, or limestone, and underlaid with fire-clay or "black-jack." To remove the coal with as little possible breakage and in the most economical way, both in regard to time and expense, certain machines have been constructed to undermine it, thus providing space for the knocking down of the coal. This is the process employed in the long wall system. In the room and pillar system undermining is frequently employed, but more often, in the Kansas mines, the space into which the coal is loosened is opened by hand and passes vertically through the coal stratum. The drilling machine is then employed to furnish openings into which charges of powder are placed, the powder being the principal factor in loosening the coal.

Transportation.—After the coal has been loosened it is immediately loaded into the cars by hand or is "buggied" to the entries where the car stands upon the track and is there loaded. The car is then pushed into a main entry where it is coupled with several other cars and hauled by mule or steam power to the foot of the shaft. It is then uncoupled from the other cars and run onto the cage of the elevator which stands at the same level as the track of the entry or main hauling way.

Hoisting of Coal.—At a given signal the hoisting engine is started and the cage with its load of car and coal is then started up the elevator shaft. If the cage be double decked, that is, has two floors and a track upon each floor, two cars are hoisted at the same time. In passing upwards, near the top of the elevator shaft and but a few inches below the level of the track in the top, the cage strikes and raises to a vertical position two plank structures, hinged at the lower sides to the shaft timbers. These two frames falling back to their former position, the cage descending rests upon them and the track on the floor of the

cage stands level with the track of the top house. The car is then pushed from the cage upon the top track, thence upon that portion of the track which is upon the top scale platform where it is weighed. After weighing the car is run to the head of the chute and dumped.

Sorting of Coal.—In sorting, the mine run coal is thrown into the chute, where it is separated by the parallel bar screens, generally into two grades: lump, and the mixture of egg, nut, and slack. In some cases other parallel bar screens still further separate the mixture of egg, nut, and slack, while in other cases the mixture is passed through a rotating screen. In many towers the screening of the coal is accomplished entirely by parallel bar screens, while a still more commonly employed system is the use of both parallel bar and revolving screens. From the respective screens the coal is conducted to box or flat cars, which are weighed and are then ready for transportation.

Drainage.—In coal mining the maintaining of the sanitary condition is absolutely essential. Good air and dry workings are prime requisites in mining. At the bottom of the shaft, and forming a continuation of it, an irregular shaped pit extends some eight or ten feet below the floor of the mine. This pit is called the "sump" and is intended as a reservoir for the surplus water of the mine. Often several sumps are necessary and are connected with the various parts of the mine by ditches or pipes. When pumps are used to remove the water they are located either in or near the sump, or in the shallow mines are located above ground in a special pump house, but in any case are connected directly with the sump from which collecting place the water is drawn from the mine. In drift mines the series of sumps above mentioned are often connected by iron pipes, acting as siphons, the sump nearest to the surface communicating with a lower level above ground. By this means all of the sumps are kept drained. In still other mines not so well equipped the water is hauled out by means of large wooden buckets or barrels.

Ventilation.—One of the most essential factors in successful underground operations of all kinds, but especially in coal min-

ing, is the maintaining of a good system of ventilation. This is especially necessary in coal mining as considerable gas is given off by the coal exposed by the mining operations. The setting up and maintaining of an air current is comparatively simple in straight passages, as in tunnels, but when a system of side passages is added, which in turn multiplies the number by the addition of other side rooms and passages, the question of ventilation becomes troublesome and perplexing indeed. By the advent of large fans operated by steam power the difficulty has been overcome in part. By means of these fans strong currents of air may be forced into or drawn from the shaft or airway. The special system of ventilation employed in any particular locality is governed entirely by the system of mining employed. As there are two general systems operated in the Kansas coal fields, the system of ventilation employed with each will be discussed.

In the long wall system of mining the main shaft is used as the down draught, or inlet for the air into the mine, while another opening into the mine furnishes the up draught, or exit for the air. This arrangement may be reversed, however, in which case the main shaft is the exit while the air shaft is the inlet for the air current. A simple reversing of the direction of the rotation of the fan changes from one method to the other. When the air enters the mine by way of the main shaft it passes in both directions—see Plate XXXIV—along the main entry to the face of the coal; at these two points the air currents divide, one-half going to the right, one-half to the left. The two currents thus produced follow the face of the coal around, gradually converging till they meet at a point midway of the face of the coal on the side and to the right and left of the main shaft. The two currents coming from opposite directions unite here and proceed to the air shaft a short distance from the main shaft along an air-way at right angles to the main entry. The air shaft is generally located to the right of the main shaft, as one looks toward the north. The air current from the left side must, therefore, cross the main entry before reaching the air shaft. This passage is effected by a cross-way being driven above the

main entry and boarded up, to prevent the return current from uniting with the fresh air there entering the mine. The two currents reuniting at the foot of the air shaft are drawn upward by the action of the fan, and thus the ventilation is maintained. If the fan is reversed there would be a reversal of the direction of the air currents, namely: the air would enter the air shaft and would be forced out of the main shaft.

In the room and pillar system of mining an entirely different system of ventilation must be employed, which is, in brief, as follows: The same arrangement may be effected in regard to the inlet and exit of the air as was spoken of in connection with the long wall system of ventilation, but as a general rule the air is forced into the mine at the air shaft and makes its escape at the main shaft. The air passes from the air shaft to the side-way or one of the main-ways. Plate XXXVI. Here the air current would divide and pass in both directions were it not for a door, *A*, placed in the entry on the opposite side from that in which the air current is to pass. Being forced to proceed in one direction it passes along the entry for a few feet until a side entry, *B*, at right angles to the main entry, is met. Here a door, *C*, placed in the main entry again changes the direction of the current, but this time into a side entry. From this point it passes to the end of the entry and from there is directed to either the right or left by air passages cut through from room to room. The air current thus follows the limit of the workings, *P P*, around until it comes to the main entry again at *D*. A door, *E*, placed in the entry again shifts the direction and prevents its return to the exit before it has passed around the mine. A cross passage, *F*, connecting the two main entries, allows the air current to pass to the opposite side of the mine. From this point it is directed through the workable portion of the mine, *G*, around to the opposite end of the main entries at *H*. Another crossway, *I*, conducts the current from one main entry to another thus allowing it to pass back again to the air shaft side of the mine. Passing through the remaining one-fourth of the mine, *K*, in a similar manner as through the previous three-fourths it finally reaches a passage way, *L*, one

entry from the one which first conducted it into the mine. This entry in turn conducts the air to the main entry from which it started. Doors, *M* and *N*, on each side of the entrance of the side entry into the main entry prevent the current from passing in either direction up or down the entry. A cross-entry, *Z*, similar to those at the extremities of the main entries conducts the air once again to the opposite side of the mine

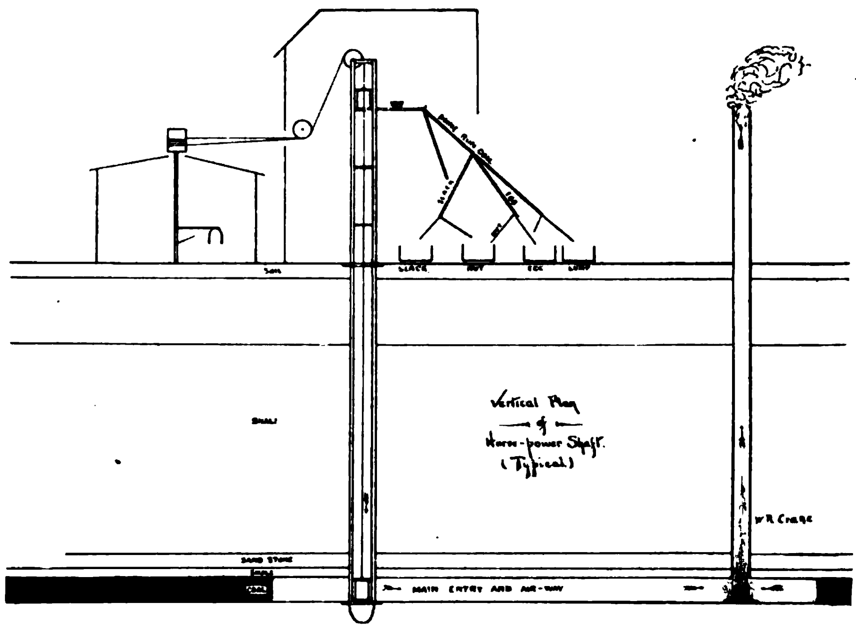
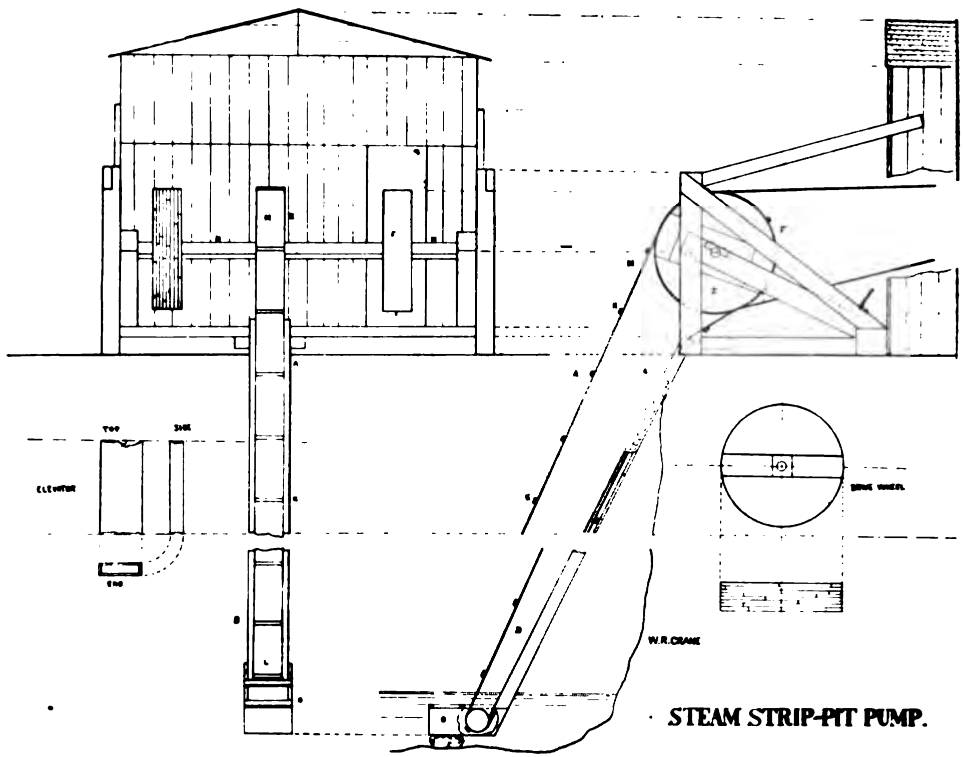


FIGURE 53. Typical Horse-power Shaft, showing a Common Method of Mine Ventilation by Furnace in Bottom of Shaft.

where it finds exit by way of the main shaft. The passage of the air across the main entry is effected by over-casts as mentioned in the long wall system.

In all coal mining operations some modification of the above described systems is employed, the principle being the same. In less extensive mining operations although the same system is used, the means of setting up and maintaining air currents differ widely. Instead of fans, fires are built below in the pit—



STEAM STRIP-PIT PUMPS,

As generally used to remove Water from Pits about Pittsburg and Weir City.

STEAM STRIP PIT PUMP, WEIR CITY.

(Photographed by Crane, 1897.)

FAN HOUSE,

As seen at Mine near Weir City. (Photographed by Crane, 1897.)

Figure 53—which, heating up the air, cause enough draft to set up an air current which introduces fresh air and expels the foul air. This method furnishes a very inefficient and exceedingly unpleasant way of furnishing fresh air to the mine.

In sinking shafts canvas sacks extending from the top of the shaft to the bottom and expanded into a wing at the top to catch the breeze furnish sufficient air for the men working below. This method is applicable only while the shaft is being sunk.

Chemical Properties of Kansas Coals.

The following details relating to the chemical composition of coal, representing the various mining districts referred to in the present report, will be presented in the same order as the geological descriptions have been presented, namely: beginning with the Cherokee and closing with the Osage City and Burlingame shales. As will be seen on examining the lists of locations, from which samples for analysis have been obtained, only the more prominent ones are given. Most of these are located in the eastern part of the state, and especially that part lying within the Coal Measures proper. A large number of localities scattered over the eastern and central portions of the state, where coal is mined on a very limited scale principally for home consumption, are not represented here.

In the following series of determinations the greatest care has been exercised both in sampling and analyzing.

Sampling.

The samples analyzed were obtained directly from the mines by the writer in person. In many instances samples were selected in the pit, which were put with samples taken from the cars at the mine, a peck of average samples being selected, representing most of the varieties, such as nut, lump, and egg. These samples were boxed and put away in a dry building where they were left for several months, in some cases from six to eight months. The coal was then removed from the boxes and broken up into pieces about the size of walnuts, then thoroughly mixed and spread out on a level surface. Pieces were then selected — not according to their appearance but according to position, that is picked uniformly from all over the lot. The selected portion was then put into a hand mortar and ground tolerably fine. After thoroughly mixing this finely ground coal, about one-half pint was taken as a fair representative of the coal

from the mine in question. The resulting one-half pint was again put into the mortar and ground until it would pass through a sieve, 1000 meshes to the square inch, giving a very fine powder.

This method of sampling, while it is not an exact average of the mine run coal, yet is a fair mean of the coal produced. Not as large a per cent. of sulphur and mineral matter will be found in coals thus chosen as in the marketable product, since there seems to be no systematic method of removing the gross impurities by the mine operators in general; only a few of the better equipped mines remove these impurities with anything like system.

The analyses herein given will probably differ somewhat from analyses made elsewhere. But it must be borne in mind that the method of sampling is one of the chief causes of this discrepancy, and also that the coal produced, by one and the same mine, will constantly vary, which fact is especially true of certain localities.

Kinds of Coal.

There are three varieties of coal found in the state, namely: (1) Bituminous, (2) Semi-Anthracite, and (3) the Lignite of the Cretaceous and Tertiary deposits of central and western Kansas.

The bituminous coal deposits of the Lower Coal Measures yield the great bulk of coal placed upon the market in Kansas. The semi-anthracite and the peacock coals are not of very much value commercially. The semi-anthracite is a variety harder than bituminous and is found in localities generally near the Missouri state line, showing traces of orographic movements of coal and associated strata. The bituminous coals of the Upper Coal Measures are not, at present, very extensively mined; while the lignite of the Cretaceous and Tertiary areas is mostly consumed by local trade.

Chemical Analysis.

As the per cent. of fixed carbon and volatile products is a basis of comparison for coal, it is not necessary to find the actual per cent. of constituents of the coal, such as carbon, oxygen, nitro-

gen, sulphur, hydrogen, iron, etc. The ordinary method is to find the actual per cent. of substances eliminated under similar conditions, thus affording a convenient and valuable means of comparison.

The per cent. composition of the ash may be determined, very readily, by the usual analytical method employed with ores, minerals, etc. The volatile sulphur must be determined by special methods, and separately, as it is driven off with the volatile matter. The determinations made are:

SUBSTANCE.	HOW DETERMINED.
1. Moisture,	By weight.
2. Volatile and Combustible matter,	" "
3. Fixed Carbon,	" "
4. Ash,	" "
5. Sulphur (volatile),	By analysis.
6. Sulphur (fixed),	" "
7. Iron as Fe_2O_3,	" "
8. Iron as Fe,	" "
9. Phosphorus,	" "

METHODS OF ANALYSIS.

Determination of Moisture.

One gram of coal is heated, in an air-bath, to 110° C., in an uncovered crucible — platinum is best — for fifteen minutes, is then cooled in a desiccator and weighed as quickly as possible, is again heated for ten minutes, then cooled and weighed. This operation is repeated to constant weight, or until the weight begins to increase.

Determination of Volatile and Combustible Matter.

Weigh out one gram of undried coal (the air-dried sample should be used in all cases), place in a platinum crucible and cover closely, heat for about three and five-tenths minutes over a Bunsen burner, then fransfer to blow-pipe flame *without cooling*, for the same length of time. The crucible is then cooled in a desiccator and weighed. The weight thus obtained subtracted from the original weight gives the volatile and combustible matter and moisture. The per cent. of moisture being known, taken from the combined weight of volatile and combustible matter and moisture, the remainder will be the volatile and

combustible matter. Several such tests may be conducted at one and the same time, as but one weighing is required.

Determination of Fixed Carbon.

To determine the fixed carbon, the crucible as last weighed, after determining the volatile and combustible matter, may be used. After all the volatile matter has been driven off the residue will consist entirely of fixed carbon and ash. The method of procedure must, therefore, be one which will produce a complete combustion of all the carbon remaining in the crucible. After such a combustion another weighing should be made, and the difference in weight of the crucible, after the volatile matter has been driven off and after the carbon has been completely oxidized, represents the weight of the fixed carbon. Care should be taken, however, not to heat the ash to too high a temperature as some of it may be volatilized.

To produce such an oxidation one of two general methods may be employed, either of which will give correct results if properly applied. These methods are: 1st, burning in free oxygen; 2d, burning in the air. Choice of the two methods should depend upon facilities at the command of the analyst; in the analyses of the Kansas coal free oxygen was employed in the combustion. The process may be described briefly as follows:

The oxygen was retained in an ordinary gas receiver, from which it was drawn through a washing apparatus to produce pure oxygen, and finally delivered through a flexible rubber tube, into the free end of which was inserted a glass tube with the outer end drawn out so as to form a small opening. The valve was then opened until a proper flow of gas was obtained. While the crucible was still red hot from a Bunsen burner the current of oxygen was carefully directed against the residue in the crucible. In this way complete oxidation of all the carbon in the crucible may be obtained in a short time. A common method of applying the oxygen in such analyses is by the use of a crucible lid through which a small tube projects. The rubber supply tube is connected with this tube on the outside, the lid placed on the crucible, when the operation can be conducted about as mentioned above. Under such circumstances

it is necessary to avoid a too rapid oxidation, or little explosions may take place with sufficient violence to throw some of the material out of the crucible, producing thereby a loss which would destroy the value of the analysis.

If the analyst should find it difficult to obtain oxygen for such a combustion equally good results may be obtained by simply heating the crucible over a Bunsen burner until the fixed carbon is entirely oxidized by the oxygen in the air. It is difficult to obtain a proper circulation of the air within the crucible and therefore to obtain a complete combustion by such a process. Where time is of any considerable value and the number of analyses to be made is great the analyst would be justified in going to a considerable expense to obtain the oxygen in order that the combustion may be carried on more rapidly than can possibly be done by using the oxygen of the air.

Determination of Ash.

If from the last weight the weight of the crucible be taken the resulting weight will be the ash.

From the ash the per cent. of iron may readily be determined. Most of the ash can easily be removed from the crucible, and if any adheres to the sides and bottom it can be removed by filling the crucible one-half full of nitric acid, HNO_3, or sulphuric acid, H_2SO_4, and gently heating it. When dissolved it may be rinsed into a beaker, into which the remainder of the ash is placed. From the resulting solution the per cent. of iron as Fe and Fe_2O_3, may be found.

Determination of Total Sulphur.

Treat finely powdered coal with concentrated nitric acid, evaporate to dryness, dilute with water, digest well and filter, wash residue thoroughly, then to filtrate add barium chloride, $BaCl_2$, which precipitates barium sulphate, $BaSO_4$. Filter, dry, and weigh the precipitate as barium sulphate, from which the per cent. of sulphur may be obtained.

Determination of Fixed Sulphur.

Heat one gram of powdered coal in a platinum crucible: first over a Bunsen burner, then over the blow-pipe flame until

all the volatile and combustible matter is driven off. The residue remaining is ash and fixed carbon, which contains the fixed sulphur. Treat the residue with concentrated nitric acid, HNO_3, as in the determination of total sulphur, the resulting barium sulphate, $BaSO_4$, will give the per cent. of fixed sulphur.

Determination of Volatile Sulphur.

The difference between the per cent. of total sulphur and fixed sulphur will give the per cent. of volatile sulphur.

Determination of Iron, as Fe and Fe_2O_3.

Treat one gram of powdered coal with hydrochloric acid to dissolve the iron, to this add sulphuric acid, and evaporate in an air-bath, until fumes of SO_2 and SO_3 (the di- and tri-oxides of sulphur) are driven off, then cool and add, with the greatest care, warm water. Rinse the resulting solution into a 200 c.c. flask, and treat with amalgamated zinc and platinum — to reduce the $Fe_2(SO_4)_3$ to $FeSO_4$, or from the -ic to the -ous form.

Test a portion of a drop with potassium sulphocyanide, KCNS, to see if all the iron exists in the -ous form. If all the iron exists in the ferrous form, titrate with potassium permanganate, $K_2Mn_2O_8$, until the liquid turns red (light).

For illustration, say that the standard solution of potassium permanganate would oxidize .0050111 parts of iron, that is 1 c.c. of $K_2Mn_2O_8$ oxidizes .0050111 parts of iron. Multiplying .0050111 by the number of cubic centimeters of $K_2Mn_2O_8$ employed in a titration we get (by multiplying by 2 or dividing by $\frac{1}{2}$) the per cent. of *iron*, Fe. In order to find Fe_2O_3, divide by .7 after multiplying by the cubic centimeters of $K_2Mn_2O_8$, and then multiplying by 2, which gives Fe_2O_3. From the above it will be seen that in the same operation both the per cent. of iron as Fe and Fe_2O_3 may be determined. The following is a problem illustrating this:

0.005011 Strength of standard solution of $K_2Mn_2O_8$.
3.500000 c.c. of $K_2Mn_2O_8$ required to oxidize the iron solution.
0.005011 times 3.50 = .017538, which divided by .7 and multiplied by 100, and the product divided by ½, gives as a quotient 5.011, which is the per cent. of Fe_2O_3.

.005011 × 3.5 = .017538. .017538 ÷ .5 = .03506: .03506 × 100 = 3.506, which is the per cent. of Fe.

Determination of Phosphorus.

Two methods were employed: (*a*) One method starts with powdered coal, before it has passed through any other process (*b*) The other method has to do simply with the ash. As most of the phosphorus exists as phosphates, being combined with inorganic parts of the coal, and as little or none of it passes off in the combustion of the volatile and combustible matter and fixed carbon, the latter is a method which seems most applicable.

Methods in Detail.—(*a*) The powdered coal is digested with concentrated HNO_3, is then filtered and precipitated with NH_4OH, which throws down the iron, Fe, aluminum, Al, etc. The precipitate is then dissolved with HNO_3 precipitated with ammonium molybdate $(NH_4)_2MoO_4$, dissolved again with ammonia, NH_4OH, and finally precipitated with "magnesium mixture," the resulting compound being magnesium pyro-phosphate, MgS_2O_4, from which the per cent. of phosphorus may readily be determined.

(*b*) Treat the ash with concentrated hydrochloric acid, HCl, dissolve the residue and add sulphuric acid, HSO_4, evaporate until sulphur di-oxide, SO_2, fumes are given off, then precipitate with ammonium chloride, NH_4Cl, and ammonium hydrate, NH_4OH, and filter, dissolve in HNO_3. Precipitate again with NH_4Cl and NH_4OH and dissolve in HNO_3, then precipitate with $(NH_4)_2MoO_4$, dissolve the precipitate in NH_4OH and precipitate with magnesium mixture. Magnesium-pyro-phosphate is thrown down, which is very soluble in water, therefore the solution must be kept concentrated.

There is little or no danger of the silicon, SiO_2, being thrown down in this method as the precipitate for phospho-molybdate is so small. The solution must be cool before adding the magnesia mixture. From the magnesium-pyro-phosphate the per cent. of phosphorus may be obtained.

Specific Gravity.

The specific gravity of coal may be determined by the ordinary method employed with insolubles, except that the coal must be soaked in water for at least 12 hours previous to taking spe-

cific weight, in order to drive out all air from the crevices and cracks. Pieces weighing from .2 and .5 grams were taken.

Remarks.

Many of the same coals, the analyses of which are given above, were analyzed by Prof. E. H. S. Bailey, of the University of Kansas, some years since. His results were published in the Transactions of the Kansas Academy of Science, Vol. XI, page 49, 1887–'88, and will be reproduced here for comparison.

He says: "If the water and ash are eliminated in the calculations from the above results, as is suggested in a recent report of the Pennsylvania Geological Survey, the coals of Kansas will be divided into five groups. In the first group are included the Cherokee coals; in the second, Fort Scott, Leavenworth and Linn counties; in the third, Osage county; in the fourth, Franklin county; and in the fifth, Cloud county." This arrangement agrees perfectly with our results, see Plates LII and LIII and accompanying text, and bears us out in saying that the value of coal, taking the per cent. of fixed carbon as the basis of comparison, decreases in passing from the southeast to the north and west.

TABLE IV.—SHOWING CHEMICAL ANALYSES OF KANSAS COALS.

Number	Name and location of mining company.	Moisture in coal	Volatile and combustible matter	Fixed carbon	Total sulphur	Fixed sulphur	Volatile sulphur	Iron as Fe_2O_3	Iron as Fe	Specific gravity	Color of ash.	Form of ash.	Ash	Phosphorus
1	Missouri, Kansas & Texas, Mineral City.	2.15	32.42	58.38	1.007	0.245	0.732	5.011	3.5077	1.338	Grayish pink	Light and flaky	7.05	Trace.
2	James O'Neil, Cherokee.	1.35	36.85	52.40	2.678	0.403	2.275	5.001	3.5087	1.399	Light reddish gray,	Quite light and flaky.	9.40	"
3	Fidelity Land and Improvement Co., Cherokee.	1.96	40.62	53.30	1.460	0.235	1.225	......	......	1.234	Dark gray	Light and loose	5.12	"
4	Columbus Coal Co., Stepville.	2.13	36.71	57.55	0.684	0.210	0.474	5.001	3.5087	1.278	Light bluish gray	Coarse ash and clinker shells.	3.61	"
5	Central Coal and Coke Co., Scammon.	3.03	33.77	57.48	1.894	0.549	1.345	......	......	1.322	Very dark colored	Flaky	5.72	"
6	Durkee Coal Co., No. 4, Scammon.	3.33	35.91	54.70	1.616	0.530	1.086	......	......	1.336	Light gray with a little reddish gray.	Light and flaky	6.06	"
7	Davis Coal Co., No. 3, Cherokee.	3.77	35.94	50.48	1.288	0.279	1.009	......	......	1.343	Very light gray	Small clinker shells.	9.81	"
8	Kansas & Texas, No. 18, Weir City.	3.57	36.96	51.84	2.551	0.254	2.297	3.722	2.6058	1.296	Pinkish gray	Quite light	7.63	"
9	Kansas & Texas, No. 47, Weir City.	3.16	39.21	53.87	0.765	0.428	0.337	......	......	1.281	Light bluish gray	Very light and flaky.	3.76	"
10	Durkee Coal Co., No. 4, Weir City.	2.34	36.88	55.69	1.056	0.403	0.653	......	......	1.299	Light gray with bluish tint.	Light and flaky	5.09	"
11	Western Coal Co., No. 2, Fleming.	2.75	34.22	57.22	0.934	0.423	0.471	......	......	1.286	Light bluish gray	Light and flaky	5.79	"
12	Hamilton & Braidwood Coal Co., No. 2, Weir City.	2.63	38.80	53.74	1.244	0.520	0.724	2.862	2.0044	1.344	Reddish gray with little bluish spots.	Coarse ash but rather light.	4.83	"
13	The Central Coal and Coke Co., No. 5, Weir City.	3.14	34.87	55.39	2.557	0.385	2.172	......	......	1.313	Grayish pink	Has tendency to clinker.	6.60	"
14	Durkee Coal Co., No. 1, Weir City.	2.57	36.34	54.99	2.787	0.823	1.964	......	......	1.319	Dark reddish gray.	Coarse but light ash.	6.10	"
15	The Excelsior Coal Co., Weir City.	2.58	36.73	55.02	1.715	0.280	1.435	......	......	1.285	Bluish gray	Has a tendency to clinker.	5.62	"
16	Santa Fe Mine, Chicopee.	3.17	34.83	55.10	1.381	0.209	1.172	4.234	2.964	1.382	Quite dark gray	Clinker shell and a little fine ash.	6.90	"
17	Santa Fe Mine, No. 1, Frontenac.	3.06	35.92	54.89	2.329	0.358	1.971	......	......	1.337	Bluish gray	Light and flaky	6.13	"

18	Kansas & Texas, No. 20 …… Pittsburg.	3.32	34.57	57.08	1.867	0.318	1.549	……	……	1.310	Reddish gray ……	Light and flaky….	5.03	"
19	Company unknown…… Pittsburg.	2.51	33.70	56.06	1.513	0.248	1.265	……	……	1.017	Part light gray; part brick color.	Quite light……	7.73	"
20	Pittsburg & Midway Coal Co., No. 4…… Midway.	2.44	33.64	56.83	3.061	0.543	2.518	4.380	3.066	1.313	Light red ……	Light and flaky….	7.09	"
21	Senott Bros., No. 3…… Cornell.	3.10	34.76	55.86	1.560	0.431	1.129	……	……	1.321	Dark brown and bluish gray.	Light……	6.28	"
22	Morganville Coal Co…… Morganville, Mo.	2.93	31.99	59.43	0.943	0.209	0.733	……	……	1.261	Light pink……	Light and flaky….	5.65	"
23	Company unknown …… Arcadia (first south of town).	2.55	33.42	56.22	2.376	0.778	1.598	……	……	1.276	Reddish to pink …	Amorphous flakes; light.	7.81	"
24	Company unknown…… Pleasanton.	4.99	36.65	54.23	0.956	0.261	0.695	2.044	1.431	1.352	Dark chrome yellow.	Light and flaky; a few clinkers.	4.13	"
25	State Mine…… Lansing.	6.58	33.52	33.91	1.197	0.368	0.829	……	……	1.319	Pinkish gray……	Light and flaky….	15.99	"
26	Blacksmith Mine…… Blacksmith.	13.42	39.83	39.29	5.550	1.136	4.414	……	……	……	Reddish brown, nearly drab.	Light……	7.46	"
27	Crane's Mine…… Dover (three miles west).	9.50	31.72	21.51	1.108	0.244	0.864	3.436	2.405	……	Light brown……	Light……	37.27	"
28	Pittsburg Commercial …… Pittsburg.	5.13	33.41	52.03	1.022	0.258	0.764	2.022	0.986	1.302	Light red ……	Clinky……	4.08	"
29	Anthracite taken from seam next to "Bell," Leavenworth.	0.82	9.14	89.03	……	……	……	……	……	1.400	White ……	Light……	1.01	"

TABLE V.—Showing Bailey's Chemical Analyses of Kansas Coals.

Location.	Number.	Water.	Volatile matter.	Fixed carbon.	Ash.	Color of ash.
Cherokee........................	1	1.54	38.06	53.44	6.96	Gray.
"	2	1.26	35.60	52.20	10.94	Drab.
"	3	1.37	37.19	50.23	11.21	Reddish gray.
"	4	2.59	39.12	51.54	6.75	Brownish.
"	5	1.85	36.11	50.94	11.60	Gray.
"	6	2.49	34.59	54.11	8.81	Light gray.
"	7	2.76	36.21	51.91	6.12	" "
"	8	2.75	36.76	53.08	7.41	Gray.
"	9	1.33	37.33	51.59	9.75	Brownish gray.
Cherokee (upper vein).........	1	2.25	34.17	49.51	14.07	Grayish brown.
" "	2	2.07	34.37	50.21	13.35	" "
" "	3	1.91	37.44	46.19	14.46	Gray.
Fort Scott	1	2.35	42.79	45.00	9.86	Reddish.
"	2	2.21	43.89	45.15	8 75	Reddish brown.
"	3	4.27	38.61	52.49	4.63	" "
Leavenworth County.........	1	3.22	41.55	49.32	5.91	Dark red.
" "	2	2.25	36.49	47.27	13.99	Light red.
" "	3	2.61	39.58	45.65	12.16	Brick color.
Linn County..................	1	1.61	38.25	48.76	11.38	Dark brown.
" "	2	2.36	40.14	48.88	8.62	Reddish brown.
" "	3	2.39	42.19	42.05	13.37	Yellowish brown.
" "	4	1.92	37.11	47.87	13.10	Red.
Osage County.................	1	7.19	40.03	41.13	11.65	Brown.
" "	2	7.71	41.56	39.92	10.81	Light brown.
" "	3	9.29	42.05	40.89	7.77	Red.
" "	4	4.70	44.86	42.11	8.33	Dark brown.
" "	5	6.75	42.79	40.97	9.49	" "
" "	6	7.27	41.45	41.35	9.93	Dark red.
" "	7	5.56	42.79	39.32	12.33	" "
" "	8	5.83	43.26	41.75	9.16	Reddish brown.
" "	9	7.36	38.33	38.54	15.77	Dark brown.
" "	10	4.91	39.58	43.17	12.34	Yellowish brown.
" "	11	7.77	40.85	40.29	11.09	Light brown.
Franklin County..............	1	7.55	44.40	37.68	10.37	Gray.
Cloud County.................	1	13.70	46.14	28.52	11.64	Dark gray.

PHYSICAL PROPERTIES OF KANSAS COALS.

The value of a coal depends largely upon what it is to be used for. The commercial value of coal differs widely from its actual value, or its value as a heat producer. In the first instance the method of mining and the ease with which it may be placed upon the market affects the value greatly, thus producing a specific value which is far from being constant. On the other hand the heat producing value of coal is to all practical purposes a fixed quantity, varying as the proportion of fixed carbon and volatile matter varies. As will be noticed by Tables IV and V, the proportion of constituents remains very nearly constant for the same horizon. We should expect therefore that the value as a heat producer would also in like manner remain constant, which is verified later in these pages. The amount of heat obtainable from coals taken even from one locality differs greatly, owing to the kind of furnace employed, the age of the furnace and boiler, and probably, most of all, upon the methods of firing, such as care of grate, ventilation, etc., which points need not be discussed here. But to the expert fireman the best indicator of correct firing is the smoke issuing from the stack. In other words incomplete combustion is responsible, in many cases, for the small amount of heat obtained, rather than the coal which generally receives most of the blame.

The duty test of a certain coal in a particular furnace will therefore give the amount of heat obtainable for the coal in that furnace, under the various conditions above mentioned, but will give data of little value for other furnaces with their attendant conditions. The results will simply be relative for the coal in the particular furnace. It will therefore appear to be necessary for the comparison of coals, first, to produce perfect combustion; second, to have the conditions governing the combustion constant.

METHOD EMPLOYED.

There are several methods employed whereby fuels may be compared according to their evaporative power; that is, to determine how many pounds or kilograms of water may be converted into steam at 212 degrees F. or 100 degrees C., under atmospheric, or 760 mm. pressure, by means of one pound or kilogram of the fuel.

Thompson's calorimetric method was employed in obtaining the following results. The method consists in burning a fixed amount, generally two grams, of coal in the midst of 1934 grams of water, or 1 gram of coal in 967 grams of water, from which it will be seen that the rise of temperature of the water will give the number of grams of water which a gram of coal will be able to convert into steam at the boiling point, 212° F., thus giving directly the evaporative power of the coal. The apparatus, which is of English make, was first constructed to burn 30 grains in 29,010 grains (30 times 967) of water, only Fahrenheit thermometers being used. Later the grain proportions were changed to gramme, so that both the Fahrenheit and Centigrade thermometers might be used, and thus conform to a standard.

Principles upon which the Method is Based.—Theory.

The principles upon which the method is based are: first, that the latent heat—the amount of heat which disappears when water is converted into steam at 212 degrees F.—equals 967 degrees F., or 537.22 gram degrees or calories; and secondly, that when coal is burned in pure oxygen the same amount of heat is evolved as when perfectly burned in the air.

These two principles may be found fully explained in any first-class text book on physics. The latent heat of water being 967° F., then 967 parts of water heated 1 degree F. indicates that there must have been sufficient heat employed to convert into steam 1 part of water at the boiling point, or 212° F. If this is true for 1° F. then it must hold good for any number of degrees F., which we will indicate by n. Therefore if 967 parts

of water be heated *n* degrees F. enough heat has been used to evaporate *n* parts of water. Thus, by noting the number of degrees rise of temperature, it is evident that we have the number of parts of water capable of being converted into steam by the heat generated. As however the possibility of error increases with the smaller amounts of fuel taken, it is better to use as large amount as is practicable without increasing the errors in other directions, as, in having too much water, etc. The proportions which seem best adapted to the foregoing method are, two grams (30.865 grains) of fuel, and of course a corresponding quantity of water — 1934 grams (967×2). The apparatus in question was constructed for these quantities.

To obtain the complete combustion of coal the necessity of having it reduced to a fine state of subdivision is evident. It must, at least, be required to pass through a sieve 1000 meshes to the square inch. Coal will not ignite and burn freely in air, not considering the possibility of its so doing in a closed space, with only a limited supply of oxygen. To obviate this difficulty the finely powdered coal is intimately mixed with several (generally 11) times its weight of potassium chlorate, $KClO_3$ and potassium nitrate, KNO_3, in the proportion of 3 to 1. The potassium chlorate and nitrate furnish oxygen for the complete combustion of the coal. The burning taking place, of course, in the midst of the water. Thus all heat derived therefrom, either in the heating of the apparatus or given off as gaseous products must needs pass first through the surrounding medium, namely, the water, before escaping into the air.

Apparatus.

The burning of the coal takes place in a copper cartridge, Figure 54, d, 1 and 2, about three inches long by three and one-fourth inches in diameter, this fitting into a cup-shaped receiver, *b*, *1* and *2*, so arranged as to allow another copper cylinder, *c*, *1* and *2*, closed at one end, to fit diving-bell-like over the first. In the closed end of the second cylinder is fastened a small tube with a valve arrangement at the top, so as to allow the water to enter or be kept out of the cylinder at will. Around

the base, that is the open end, a fraction of an inch above the edge, is a row of holes through which the gaseous product escapes. The vessel in which the combustion takes place and into which the above described apparatus is placed is a cylindrical, thick glass tube, formed into a foot below, lipped above, and graduated to hold 1934 or 2000 grams (2 litres) of water, *a*, *1*, Figure 54. The temperature is determined by means of a thermometer reading to $\frac{1}{10}$ of a degree F. A complete description of this method is given in the Encyclopædia Britannica, under the head of "Coal."

Details of Testing.

The same coals were employed in the physical test that were used in the chemical test. See p. 270, for methods of sampling. After having been reduced to a fine powder and sifted, the

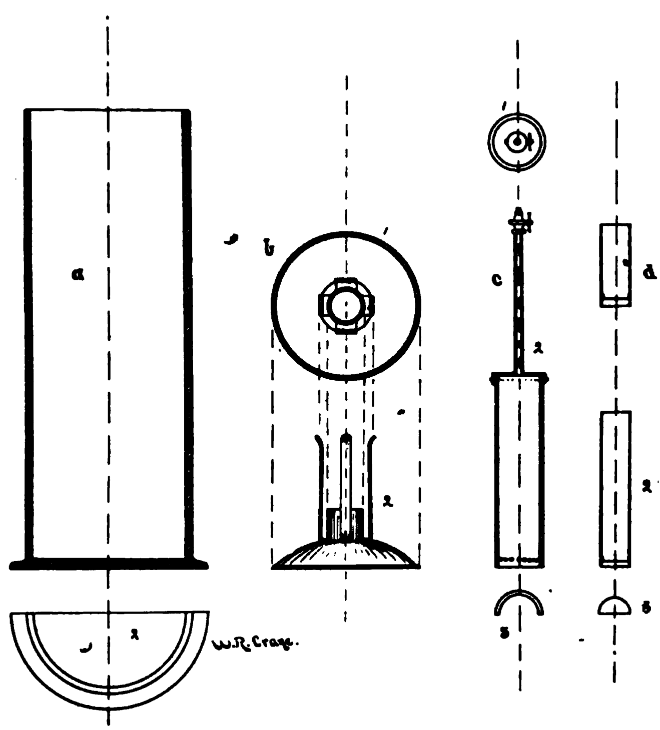


FIGURE 54. Vertical Sections and Horizontal Plans of Containing Jar, Foot, Valved Cap, and Cartridges of Thompson's Calorimeter.

sample is weighed on a delicate balance. Two portions of two grams each are taken, a duplicate test being made in most cases. The potassium chlorate and nitrate, having been dried and thoroughly triturated, are mixed in the proportion of 3 to 1,—16.5 grams $KClO_3$ and 5.5 grams KNO_3. To this mixture add the two grams of coal and mix intimately by means of a spatula. A smooth even grained glass plate is found to be the most satisfactory mixing board. When the three substances have become thoroughly intermixed, which fact can be determined from the grayish color of the powder, load into a cartridge, pressing well together with rammer but not tamping hard. The whole mass should be relatively compact but not packed together at intervals, which would produce very uneven and unsatisfactory burning. After the cartridge is loaded, take a knife blade or any flattened point and loosen up the powder in the center a quarter of an inch in depth; into this loosened powder press the fuse, heaping up the mixture around the base of it, but avoid pressing, in which case the fire is liable to be smothered out.

The fuse should be of sufficient length to insure the operator time to light and place the apparatus in the vessel of water. If the charge should begin to burn before immersed in the water the test is worthless. Each operator must judge for himself from experience what the proper length of fuse should be. The writer has found that the most satisfactory fuse — one which is more certain than the fuse generally employed — is made by taking a mixture of potassium chlorate, potassium nitrate, and coal, in the proportion of 2½, 1½, and 1 parts. Mix thoroughly and triturate so that the mixture will pass through a sieve 1000 meshes to the square inch. Take a quarter inch strip of tough tissue paper, moisten, and spread out upon a smooth surface, then sift some of the above mentioned mixture upon the strip and roll into a long tube. When nearly dry twist into a long tight string. This form of fuse has proved eminently satisfactory, seldom failing to ignite the charge, while it burns with a surprising regularity and freedom. The charge should ignite

by the time the furnace reaches the bottom of the jar. Otherwise the fuse will not have been rightly timed. One must learn from practice rather than from precept what is the proper length for fuse, form of fuse, etc.

If the charge is properly ignited dense white fumes of carbon monoxide, CO, carbon dioxide, CO_2, and sulphur dioxide, SO_2, etc., the result of the chemical union of the carbon of the coal with the chlorate and nitrate, will be given off. Owing to the construction of the apparatus these fumes are forced to pass through the whole length of the column of water, from the bottom to the top, thus affording ample opportunity for the water to extract heat therefrom and attain a temperature common to both. Violent burning is not conducive to good results, neither is too slow burning. In the former case water is apt to be thrown out of the jar by the too rapid evolution of gases; in the latter case, especially when the time of burning extends up to four or five minutes, there is chance for loss of heat by radiation.

There are two ways to regulate the rate of combustion: first, by care in charging; second, by varying the proportion of the oxygen mixture. A well tamped charge burns less violently than one that has received little or no tamping, which fact is readily shown by tamping at intervals. Such a charge when ignited will burn very irregularly, but always less violently at the compressed portion. It has been suggested by some that 22 parts of oxygen mixture be used. This rule will not always hold good, for in some coals tested by the writer 22 parts would not produce combustion. In some such instances more of the oxygen mixture was required, while in others considerably less would produce the required result; in the former case often as high as 27 parts of the oxygen mixture were required, while in the latter not more than 18 parts. A thermometer is placed in the containing vessel as soon as the furnace is immersed, and is allowed to remain there until the temperature reaches the highest point possible, or in other words until the heat generated by the combustion has diffused throughout the apparatus and sur-

rounding water and all parts have attained the same temperature. While the furnace is being immersed the stop cock in the above mentioned tube fitting to the diving-bell cap must be kept closed, so that no water can come in contact with the charge. As soon as the burning ceases open the stop cock and allow the water to enter and come in contact with the heated parts, cartridge, etc. Then churn the furnace up and down so as to distribute the heat evenly throughout the vessel.

The duration of burning should be noted. To get the time accurately there should be two persons: one to give the signal as the first indications of combustion are noticed, and a corresponding signal when the bubbles cease to escape. The difference of these two observations will give the duration of burning. The temperature of the room should be noted, and the temperature of escaping gas. The color of fumes, and the color and relative quantity of ash as seen floating in the water should also be noted, although these data do not play any part, directly, in reaching the results, yet they are always attendant upon the result and give a very approximate indication of the value of the coal as a heat producer. The temperature of the water in the testing vessel must, of course, be noted just before the furnace is immersed for combustion. The temperature of the water should always be lower than that of the room — six degrees has been given as about the right difference, yet from observation it has been shown to make little or no difference if the temperature is not allowed to fall below 1½° to 2° F. as a difference.

Corrections.

The corrections upon the instrument have been determined as follows:

1. "*Heat absorbed by the gases of combustion.*— This amount can only be approximated. The volume of the escaping gas is about 3300 c.c. The rate of combustion is slow enough to allow these gases to issue into the air at about the temperature of the water, or about 5.4° F. above the room temperature. Assuming their specific heat to be on the average that of carbon

dioxide, for about 12° rise in temperature 0.9 per cent. must be lost."[7]

2. *The heat of the decomposition of the potassium chlorate and nitrate.*—Although this quantity cannot be determined exactly yet it can be quite closely approximated. The method employed is as follows: The combustion of two grams of the purest carbon obtainable — lamp black — gave 7930.4 thermal units or calories. It has been shown that the calorific powers of different forms of pure carbon, as determined by Favre and Silbermann[8] are as follows:

Forms of Carbon.	Calorific Power.	Analyst.
Wood charcoal	8,080.00	Favre and Silbermann.
Gas retort carbon	8,047.30	" "
Artificial-graphite	7,762.30	" "
Native graphite	7,796.60	" "
Diamond	7,770.10	" "
Carbon vapor	11,214.00	" "
Lamp black	7,930.40	W. R. Crane.

Taking lamp black, as being one of the purest forms of carbon, and carbon vapor, and averaging them, we have as nearly as can be determined the calorific power of pure carbon. This mean is 9572.20 calories. (A calorie is a gram of water raised 1 degree C.) The total loss therefore must be very nearly 15 per cent.

As will be shown later in these pages, the loss due to absorption by the apparatus is about 1.18 per cent., and as was mentioned in (1), a loss of 0.9 per cent., thus making a loss of 2.08 per cent. due to causes other than the decomposition of the oxygen mixture. The loss due to the decomposition of the oxygen mixture must therefore be 12.92 per cent. (15—2.08).

3. The error due to weighing the coal is practically negligible as the balances used read to .05 milligram and an error of 1 milligram would cause a loss of .005 part of 1 per cent.

4. The error arising from taking too large or too small a quantity of water would not amount to over 1½ to 2 tenths of 1 per cent., a negligible quantity also.

7. Blake, Prof. L. I.: "Evaporative Power of Kansas Coals," in Trans. Kans. Acad. Sci., vol. xi, 1887-'88, Topeka, 1889.

8. Groves and Thorp: Chemical Technology, vol. i, Fuels, p. 707, Philadelphia, 1889.

5. Loss of heat from radiation and conduction was determined by experiment. 1934 grams of water were placed in the testing vessel, the temperature raised to about the average temperature obtained in testing, and the rate of cooling determined. The results are as follows:

Time.	Thermometer in Calorimeter.	Temp. of Room.
8:30 A. M	87.90 F	74.8 F.
8:35 A. M	87.85 F	74.8 F.
8:40 A. M	87.85 F	74.8 F.
8:50 A. M	87.00 F	74.9 F.
9:30 A. M	86.50 F	75.0 F.
10:00 A. M	85.00 F	75.3 F.
1 hr., 30 min	2.9 F	......

The loss would therefore be 0.03° F. for one minute. An average burning requires about two minutes. A few extend from three and a half to four minutes. Taking the time a little above the average, we will say three minutes, then the loss would be .09° or 0.1° F. (3 times .03° F.)

6. *The heat absorbed by apparatus.*— Several tests were made upon each of the separate pieces of the furnace to determine the amount of heat absorbed by them. The following tables give the results:

TESTS ON CAP.

No. 1.—Temperature of cap	208.	deg. F.
" of water before heating	70.	"
" of water after heating	71.04	"
Difference in temperature of water	1.04	"
" 1.04 ÷ 208 = .005; or, .5 per cent.		
No. 2.—Temperature of cap	206.6	deg. F.
" of water before heating	70.4	"
" of water after heating	71.4	"
Difference in temperature of water	1.04	"
" 1.04 ÷ 206.6 = .0047; or, .47 per cent.		
No. 3.—Temperature of cap	201.2	deg. F.
" of water before heating	69.8	"
" of water after heating	70.7	"
Difference in temperature of water	0.9	"
" 0.9 ÷ 201.2 = .0044; or, .44 per cent.		

Average per cent. heat absorbed by cap, .47

TESTS ON RECEIVER OR BASE.

No. 1.—Temperature of base	208.	deg. F.
" of water before heating	69.8	"
" of water after heating	70.7	"
Difference in temperature of water	0.9	"
" 0.9÷208=.0043; or, .43 per cent.		
No. 2.—Temperature of base	199.4	deg. F.
" of water before heating	69.7	"
" of water after heating	70.7	"
Difference in temperature of water	1.0	"
" 1÷199.4=.005; or, .5 per cent.		
No. 3.—Temperature of base	205.7	deg. F.
" of water before heating	69.8	"
" of water after heating	70.8	"
Difference in temperature of water	1.0	"
" 1÷205.7=.0048; or, .48 per cent.		
No. 4.—Temperature of base	200.3	deg. F.
" of water before heating	69.8	"
" of water after heating	70.7	"
Difference in temperature of water	0.9	"
" .9÷200.3=.0044; or, .44 per cent.		

Average per cent. heat absorbed by base, .46

TESTS OF SMALL CARTRIDGE.

No. 1.—Temperature of cartridge	209.3	deg. F.
" of water before heating	69.8	"
" of water after heating	70.4	"
Difference in temperature of water	0.6	"
" 0.6÷209.3=0 0028; or, .28 per cent.		
No. 2.—Temperature of cartridge	203.9	deg. F.
" of water before heating	69.8	"
" of water after heating	70.3	"
Difference in temperature of water	0.5	"
" 0.5÷203.9=.0024; or, .24 per cent.		
No. 3.—Temperature of cartridge	206.6	deg. F.
" of water before heating	69.8	"
" of water after heating	70.3	"
Difference in temperature of water	0.5	"
" 0.5÷206.6=.0024; or, .24 per cent.		

Average per cent. heat absorbed by cartridge, .25

TESTS ON LARGE CARTRIDGE.

No. 1.—Temperature of cartridge	212.	deg. F.
" of water before heating	69.8	"
" of water after heating	70.3	"
Difference in temperature of water	0.5	"
" 0.5÷212=.0023; or, .23 per cent.		

No. 2.—Temperature of cartridge	210.2	deg. F.
" of water before heating	69.8	"
" of water after heating	70.4	"
Difference in temperature of water	0.6	"
" 0.6÷210.2=.0028; or, .28 per cent.		
No. 3.—Temperature of cartridge	186.8	deg. F.
" of water before heating	69.9	"
" of water after heating	70.4	"
Difference in temperature of water	0.5	"
" 0.5÷186.8=.0027; or, .27 per cent.		
Average per cent. heat absorbed by cartridge, .26		

SUMMARY.

Heat absorbed by receiver	.46	per cent.
Heat absorbed by cap	.47	"
Heat absorbed by cartridges (average)	.25	"
Total amount of heat absorbed	1.18	per cent.

In finding the amount of heat absorbed by the apparatus the following method was employed. The tests were made on the separate pieces of the furnace instead of the whole furnace together for the reason that they could be handled much more readily and rapidly, which are both very important points to be considered in the determinations. Each place was heated to a constant temperature in a copper oven, *AB*, Figure 55. The oven is about eight inches high, twelve inches long, and six inches wide. The door, *BC*, which takes up one whole side of the oven, is hinged on the shorter side, *KL*, thus opening lengthwise of oven. Two strips of copper, *OP*, are fastened lengthwise of the door, forming a groove an inch and a half in width. A corresponding groove, *ZR*, is arranged in both ends of the oven and on the stationary side of it. The pieces of the apparatus are so placed in these grooves that when the oven is turned upon its side—the door, forming the bottom (see dotted lines)—the piece falls into the groove, then when the door is opened it glides down the inclined plane of the door guided by the groove and is thus introduced into the receiving vessel. Figure 55.

Method in Detail.

Stand the oven upon a tripod and introduce a thermometer into the top of the oven, through a hole prepared for it, *MN*, Figure 55. Heat by means of a Bunsen burner. Place the

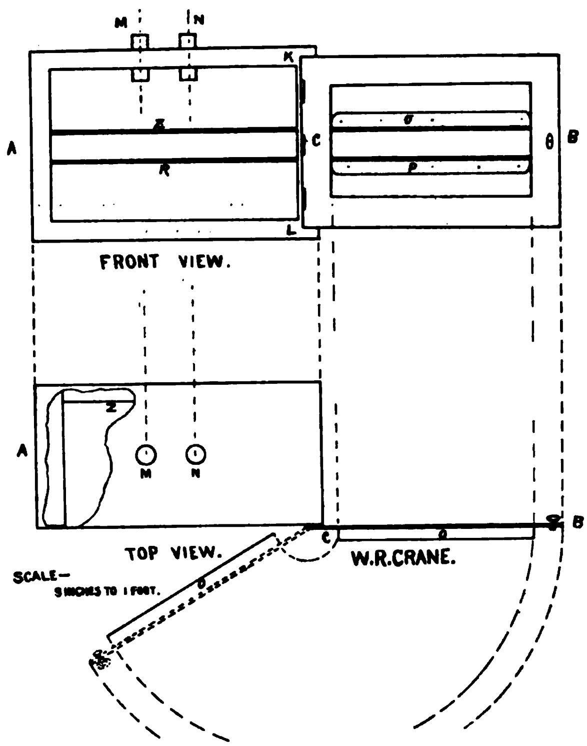


FIGURE 55. Front view of Copper Oven, with door open, showing grooves on door and back of oven; also top view, with a portion of top cut away, showing grooves.

piece to be tested in the above mentioned grooves, close the door, and by regulating the supply of gas, etc., raise to constant temperature. In the meantime fill the testing vessel with the same quantity of water as is used in actual tests with coal. Note the temperature of the water in the vessel. By this time the piece of apparatus should have reached a temperature common with the oven and contained air. Remove the thermometer from the oven, lift the oven from the tripod, and place directly above vessel of water, then strike the latch, which holds the oven door shut, against the edge of jar. This unlatches door, which will now be resting upon the edge of the vessel. By lifting the oven the door is opened, although still resting upon the edge of the vessel, whereupon the piece of ap-

paratus will slide quickly and smoothly down the groove into water. By a little practice the apparatus may be changed from the constant temperature of the oven to the water almost instantaneously and, what is of the most importance, without an appreciable loss of temperature, the temperature seldom falling more than 2 tenths of a degree in transit. The method is one very readily employed and extremely simple, while the results, as will be seen from the above table are quite constant.

The total loss of heat in the calorimetric method is about 15 per cent, the oxygen mixture being responsible for 12.92 per cent., while the remaining 2.08 per cent. is due to other causes mentioned above. A prominent error both in the experimental tests and the calculations of the calorific powers of fuels lies in the fact that the carbon of the fuel does not exist either as a solid or as a gas alone, but as both, the difficulty experienced being, that the per cent. of either the gas or solid is a decidedly variable quantity.

It will be seen from the above calculations that the correction of ten per cent. of the manufacturers of the instrument and that generally employed is small, also that the correction as determined by Professor Blake is large. As the calculations made heretofore, on Kansas coals, have been made by taking one or the other of these corrections, it might be well to give the results of the application of all three of them, which results will be found side by side in the table of tests.

Heat of Combustion by Calculation.

The need of a simpler method of finding the calorific power of coal will be recognized by any one who attempts the actual tests with any of the methods generally employed. There are several methods by means of which the heat of combustion of fuels, especially coals, may be determined by calculation. The two most important are, the method of M. Carnut, chief engineer to the Northern Steam Users' Association, of France, and Dulong's Laws. As M. Carnut's law gives us a means of arriving at results more approximately correct than Dulong's

we will consider that law only. The formula by which the law is expressed is as follows:

$$Q = 8,080\ C' + 11,214\ C'' + 34,462\ H.$$

Where $Q =$ the total quantity of heat = the calorific power desired; $C' =$ the fixed carbon; $C'' =$ the volatile carbon (hydrocarbons) found in coal; and $H =$ the hydrogen.

The elucidation of this formula will not be undertaken here, as it requires demonstration too lengthy and complex for the intended scope of this work.

The law is quite simple and easily applied, one advantage being that liquid fuels may also have their calorific powers determined by similar calculations. The principal cause of error is the fact that the calorific value of the hydrocarbons (volatile carbon) is not distinguished according to the temperatures at which they are set free.

From the formula it will be seen that the quantity, H, must be known, which quantity was not determined in the chemical analyses of the coals under consideration. It will therefore be impossible to calculate the calorific power of the coals by this method.

In the following table will be found the results obtained by Prof. L. I. Blake, of the University of Kansas, who tested some of the coals from the same localities as those used in the tests made by this Survey. As will be seen on examining the following table, the per cents. (correction) are ten and thirty, which have been taken into consideration in the above tests, so that a comparison of the two sets of tests may readily be made. See page 293.

From his results Professor Blake deduces the following facts: "The coals depreciate in their steam producing power from the southeastern part toward the north and west." This deduction corroborates in a general way our own conclusions, as already expressed.

Number	Loca[lity]	Pounds of water at 212° F. or 100° C. evaporated per pound of coal burned. Correction on apparatus. 10%	30%	15%	Calculated calorific power.	Time of day when the following data were taken	Calories	Liters of water evaporated per kilogram of fuel	Rate of radiation of heat.
1	Fleming	13.09	15.4	13.6	....	11 to 12 a. m.	6390.3	13.6	0.03 ° F. per min.
2	Cornell	12.43	14.69	13.0	....	1:00 p. m.	6068.1	13.0	" " "
3	Midway	12.32	14.56	12.88	....	2:00 "	6014.4	12.88	" " "
4	Leavenworth	10.78	12.74	11.27	....	10:00 a. m.	5322.6	11.27	" " "
5	Pittsburg	12.87	15.21	13.45	....	10:30 "	6282.9	13.45	" " "
6	Chicopee	12.87	15.21	13.45	....	10:45 "	6282.9	13.45	" " "
7	Cherokee	14.96	17.68	15.45	....	11:00 "	7303.2	15.45	" " "
8	Weir City	13.09	15.4	13.6	....	11:30 "	6390.3	13.6	" " "
9	Pleasanton	11.88	14.04	12.42	....	8:30 "	5799.6	12.42	" " "
10	Weir City	13.64	16.12	14.26	....	8:45 "	6658.8	14.26	" " "
11	Stippville	14.63	17.29	15.3	....	8:50 "	7142.1	15.3	" " "
12	Weir City	13.31	15.73	13.9	....	9:00 "	6497.7	13.9	" " "
13	Pittsburg	12.32	14.56	12.88	....	9:25 "	6014.4	12.88	" " "
14	Scammon	13.75	16.25	14.35	....	9:40 "	6712.5	14.35	" " "
15	Arcadia	13.42	15.86	14.0	....	9:50 "	6551.4	14.0	0.02 " "
16	Weir City	12.87	15.21	13.45	....	10:00 "	6282.9	13.45	" " "
17	Weir City	12.65	14.95	13.22	....	10:15 "	6175.5	13.22	0.025 " "
18	Cherokee	13.09	15.4	13.6	....	10:20 "	6390.3	13.6	0.100 " "
19	Weir City	12.76	15.08	13.34	....	10:40 "	6229.2	13.34	0.04 " "
20	Mineral City	12.98	15.34	13.55	....	10:50 "	6336.6	13.55	0.02 " "
21	Morganville,	12.87	15.21	13.45	....	11:00 "	6282.9	13.45	0.01 " "
22	Scammon	12.21	14.43	12.76	....	11:10 "	5960.7	12.76	0.012 " "
23	Frontenac	12.43	14.69	13.0	....	11:25 "	6068.1	13.0	0.03 " "
24	Cherokee	11.96	14.17	12.53	....	11:38 "	5853.3	12.53	0.035 " "
25	Weir City	12.76	15.08	13.34	....	11:45 "	6229.2	13.34	0.036 " "
26	Neosho Rapid	12.32	14.56	12.88	....	12:00 "	6014.4	12.88	0.024 " "
27	Carbondale	11.44	13.52	11.96	....	2:00 p. m.	5584.8	11.96	0.03 " "
28	Scranton	11.33	13.39	11.84	....	2:25 "	5531.1	11.84	" " "
29	Osage ....idue..	9.79	11.57	10.23	....	2:40 "	4979.3	10.23	" " "
30	Osage	11.22	13.26	11.73	....	3:00 "	5476.4	11.73	0.031 " "
31	Pleasanton	12.54	14.82	13.11	....	3:25 "	6121.8	13.11	0.03 " "
32	Pleasanton	13.31	15.73	13.91	....	4:05 "	6497.7	13.91	0.025 " "
33	Burlingame	11.77	13.91	12.3	....	8:00 a. m.	5745.9	12.3	0.01 " "
34	La Cygne	11.66	13.78	12.19	....	8:40 "	5692.2	12.19	0.031 " "
35	Burlingame	12.10	14.30	12.65	....	8:55 "	5907.0	12.65	0.033 " "
36	La Cygne	13.75	16.25	14.37	....	9:40 "	6710.2	14.37	0.03 " "
37	Unknown	10.45	12.35	10.92	....	11:00 "	5101.5	10.92	0.01 " "
38	Burlingame	11.88	14.04	12.42	....	9:00 "	5799.6	12.42	0.02 " "
39	Burlingame	11.11	13.13	11.61	....	10:30 "	5423.7	11.61	0.028 " "
40	Osage City	11.44	13.52	11.96	....	2:00 p. m.	5584.8	11.96	0.029 " "
41	Osage City	10.56	12.48	11.04	....	8:15 a. m.	5155.2	11.04	0.03 " "
42	Osage City	10.01	11.83	10.46	....	8:40 "	4886.7	10.46	0.03 " "
43	Fort Scott	13.42	15.86	11.73	....	3:00 p. m.	5551.4	11.73	0.036 " "

TABLE VII.—BLAKE'S PHYSICAL TESTS OF KANSAS COALS.

LOCALITY.	Number	Pounds of water at 212° F. evaporated per pound of coal. Correction on apparatus. 10 per ct.	30 per ct.	Duration of burning.	Remarks.
Cherokee coals	1	13.53	15.97	40 seconds.	
" "	2	13.64	16.10	45 "	
" "	3	13.01	15.35	45 "	
" "	4	13.31	15.71	60 "	
" "	5	13.31	15.71	60 "	Violent burning.
" "	6	13.86	16.36	65 "	
" "	7	13.53	15.97	50 "	Violent burning.
" "	8	13.94	16.45	75 "	
" "	9	13.42	15 84	90 "	
" " (upper vein) Pittsburg	1	12.43	14.67	55 "	
" " " "	2	12.76	15.06	45 "	
" " " "	3	13.31	15.71	60 "	
Fort Scott coals	1	13.64	16.10	65 "	
" "	2	13.09	15.45	60 "	
" "	3	13.86	16.35	55 "	
Leavenworth coals	1	13.36	15.76	75 "	
" "	2	12.25	14.46	80 "	Brown residue.
" "	3	13.86	16.35	65 "	
Linn county coals	1	12.76	15.06	60 "	
" "	2	12.76	15.06	70 "	
" "	3	12.87	15.49	80 "	Brown residue.
" "	4	12.54	14.80	75 "	
Osage county "	1	11.88	14.02	110 "	Brown residue.
" "	2	10.96	12.93	90 "	" "
" "	3	12.98	15.32	120 "	" "
" "	4	11.66	13.76	120 "	" "
" "	5	12.43	14.67	120 "	" "
" "	6	11.99	14.15	165 "	" "
" "	7	11.66	13.76	120 "	" "
" "	8	11.88	14.02	120 "	" "
" "	9	11.55	13.63	70 "	" "
" "	10	11.44	13.50	80 "	" "
" "	11	11.66	13.76	105 "	" "
Franklin county coals	1	12.32	14.54	125 "	
Cloud county "	1	9.90	11.68	135 "	

CURVES AND DIAGRAMS SHOWING RELATIVE VALUE OF KANSAS COALS.

The curves shown by Plates LII and LIII have been constructed from the highest average per cents. of fixed carbon and calorific power of coals, found by analysis, in the localities given below. Curves No. 1 have been platted by means of the two quantities, distance and per cent. of fixed carbon and calorific power (the number of pounds of water which can be evaporated by one pound of coal), found in Kansas coals, the starting point being Columbus on the south, and the distances being laid off in miles to the north. Curves No. 2 are platted in like manner except that the distances are laid off from the east to the west, with Pittsburg as the starting point on the east.

The platting is accomplished as follows: In curves No. 1, starting with no miles, that is, with a certain point on the south, the exact positions of towns or mining camps is located in miles to the north. The value of the coals mined at these localities, as determined by analysis, determines the position of the point to the right or left of the initial position or starting point. Curves No. 2 are platted in the same way, except that the points representing the localities from which coal has been taken for analysis, extend to the west of the initial or starting point. As will be seen in Plates LII and LIII, on the left hand side are found curves No. 1, extending from the south to the north, while on the right hand side are found curves No. 2, extending from the east to the west, both curves being put upon the same plat for convenience.

Curve No. 1. Plate LII.

In No. 1 it is seen that the value of the coal remains quite constant for the first ten miles, then decreases in value fully 6 per cent. in the next few miles, this decrease taking place in

—

the southern part of Crawford county, at Cherokee. From this sudden drop of 6 per cent. it as quickly makes a rise of nearly 8 per cent., which rise occurs at Fleming. For the succeeding twenty miles the increase and decrease remain very nearly constant. From a point approximately thirty-five miles north of Columbus to another point in the neighborhood of one hundred miles north the decrease is at a nearly constant rate of $\frac{3}{10}$ per cent. to the mile. From this point—.375 per cent.—it rises abruptly to 43 per cent. at an increase in distance of only twelve miles, or $\frac{5}{10}$ per cent. to the mile. From the 115 mile mark it decreases a trifle over $\frac{8}{100}$ of one per cent. per mile in passing a distance of thirty-five miles, $\frac{6}{10}$ per cent. per mile being the rate of decrease from the 150 mile mark to Cloud county—the most western point of which we have any record. Curve No. 1 was constructed from the average per cent. of fixed carbon found in the coals of the following localities, numbered in direct order from Columbus northward: (1) Stippville, (2) Scammon, (3) Mineral City, (4) Weir City, (5) Cherokee, (6) Fleming, (7) Chicopee, (8) Pittsburg, (9) Frontenac, (10) Cornell, (11) Arcadia, (12) Fort Scott, (13) Linn county, (14) Franklin county, (15) Osage county, and (16) Cloud county.

Curve No. 2. Plate LII.

Curve No. 2 starts at Pittsburg, at a point about eight miles from the east line of the state. The value of the coal—as determined by the fixed carbon—remains fairly constant to a point ten miles west of the state line. From this relatively high point of 57.5 per cent., it falls to 50.5 per cent. without any appreciable change in distance. This decrease of 7 per cent. occurs at Cherokee. From this point it decreases rapidly—at a rate of nearly .5 per cent. per mile—to a point thirty-five miles west of Pittsburg. An increase of .2 per cent. occurs from the 42.5 mile point to the 72.5 mile point, west of Pittsburg. From the 43 per cent. mark a fall of 11 per cent. is noticed, which leaves us at a point 165 to 170 miles west of Pittsburg. This curve was plotted from per cents. of fixed carbon found in coals taken from the following localities, which are

numbered from Pittsburg westward: (1) Pittsburg, (2) Fleming, (3) Weir City, (4) Scammon, (5) Cherokee, (6) Franklin county, (7) Osage county, (8) Cloud county.

From the above it will be readily seen that the value of Kansas coals decreases in a general way in passing from the southeast to the north and west, the highest per cent. reached being 58.4, the lowest 28.4, making a difference of 30 per cent. for a range of 160 to 165 miles, or a decrease of nearly .2 per cent. per mile.

It is interesting to note at this point that the decrease in per cent. of fixed carbon bears a very close relation to the variation in per cent. of calorific power of the same coals, which may be seen on examining the curve of calorific powers, Plate LIII.

Curves Showing Variation in Calorific Power.

Curve No. 1. Plate LIII.

In curve No. 1, it is seen that the number of pounds of water varies from 13.5, during the first twenty miles, to very nearly 16 pounds. From the twenty-odd mile mark to the fifty mile mark the variation is fairly constant, gaining during the last half of the thirty miles what was lost during the first half. From the fifty mile mark a rapid decrease of nearly 3 per cent. or 3 pounds of water is noted, from which point there is a rapid increase of 2.7 per cent. From the eighty mile mark for the next one hundred miles a decrease of 2.4 per cent. is noticed, and from this point on to the 150 mile mark a gradual decrease is seen, which is about .4 per cent. for a distance of forty or fifty miles, making an average of $\frac{1}{10}$ of 1 per cent. to the mile.

From the above a decrease of $\frac{26}{100}$ per cent. is noted for the approximately one hundred and fifty miles passed over.

Curve No. 2. Plate LIII.

In curve No. 2, the initial point has a value of 13.4 per cent., from which point a rapid rise of 2.1 per cent. to six miles occurs. From approximately fifteen miles west of Pittsburg a very decided decrease in calorific power occurs which is traceable only to the seventy mile mark. As the coals west of this point have

not as yet been analyzed, our record from this point westward must of necessity stop.

The localities from which the data for curve No. 1 were obtained are: (1) Stippville, (2) Scammon, (3) Mineral City, (4) Weir City, (5) Cherokee, (6) Fleming, (7) Chicopee, (8) Pittsburg, (9) Frontenac, (10) Cornell, (11) Arcadia, (12) Fort Scott, (13) Pleasanton, (14) La Cygne, (15) Osage City, and (16) Leavenworth.

For curve No. 2, the localities are as follows: (1) Pittsburg, (2) Fleming, (3) Weir City, (4) Scammon, (5) Cherokee, and (6) Osage City.

RESUME.

From the above it will be seen that the heating value of the Kansas coal decreases quite perceptibly in passing from the south and east to the north and west, which decrease corresponds very closely to the decrease in the per cent. of fixed carbon. This fact has also been remarked by Prof. L. I. Blake[9] of the University of Kansas, in his work on the calorific values of coal, and by Prof. E. H. S. Bailey[10] in his chemical work on the same coals.

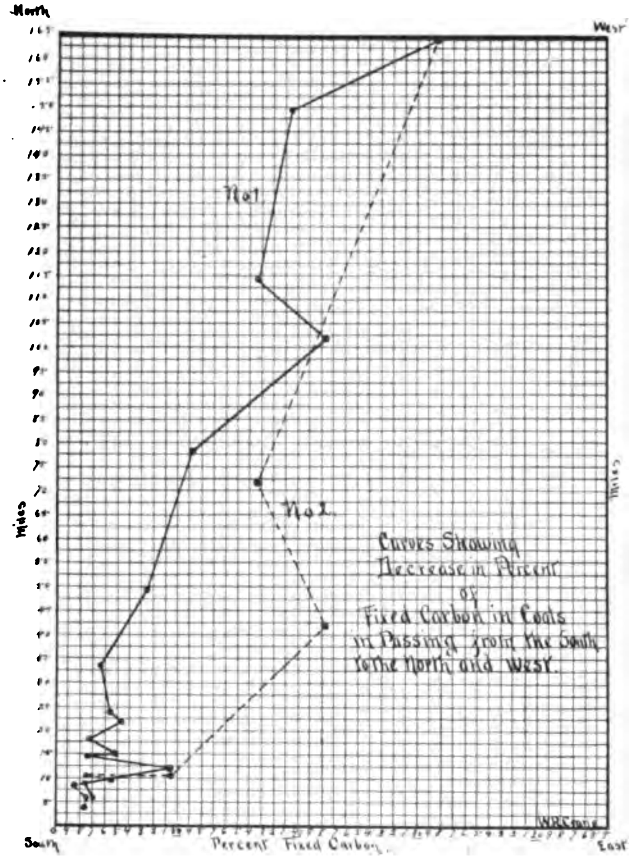
The depreciation in value of the Kansas coals is probably due to several causes, the most important of which are: Difference in the age of the coal beds and a change in the quality and quantity of the coal producing vegetation, coupled with a change in the conditions of deposit.

A glance at the coal map of Kansas—Plate VIII—will show that the coal beds belonging to the older geological formations lie in the extreme southeastern part of the state, and from the sections given it will been seen that these beds soon pass out of reach of any mining operation which might be attempted outside of the "Cherokee shales" area. The coal beds lying to the north and west belong to more recent geological formations. They are thinner, are not so hard as the coals belonging to the lower formations, and as a general rule have more impurities in them, which is shown by an increase in the

9. Prof. L. I. Blake, Kans. Acad. Sci., vol. xi, p. 42, et seq.
10. Prof. E. H. S. Bailey, Kans. Acad. Sci., vol. xi., p. 45, et seq.

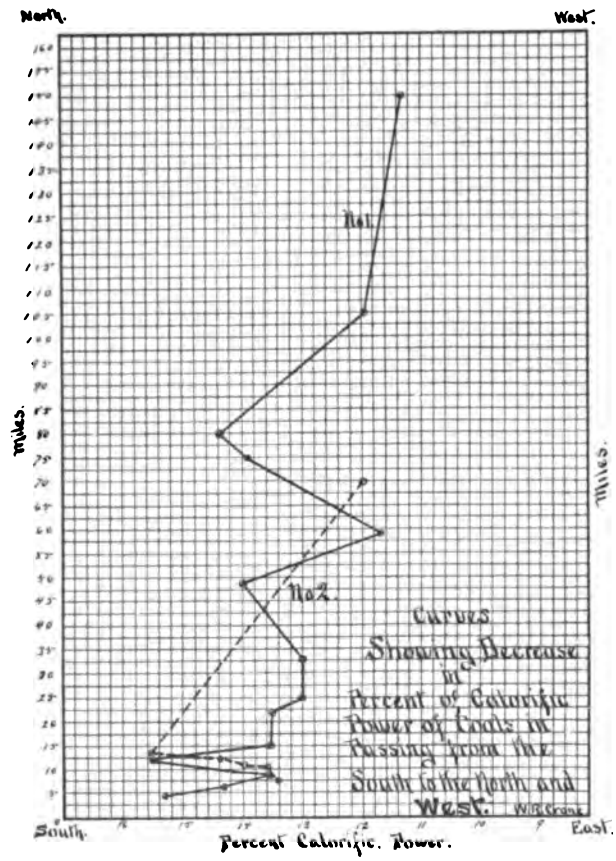
per cent. of ash. The coal beds of the lower and therefore older formations have been subjected to a higher pressure, as shown by the clay veins in the shale and also by the foldings. The upper coal beds show no signs of any orographic movements. This fact will of itself account for the difference in the degree of hardness noticed, if not for the difference in per cent. of constituents.

Whether there was any marked change in the quality of the coal producing vegetation is not so easily determined as the fact regarding the quantity of vegetation. That there was a marked decrease of coal producing vegetation is easily seen by the thinner strata of coal. With a less rapid deposition of vegetable matter a change in the conditions of deposition would of necessity occur, which change would in many cases seriously affect the chemical and physical properties of the resulting coals.



DIAGRAMS SHOWING DECREASE IN PER CENT. OF FIXED CARBON IN COAL OF THE STATE.

The per cent. of fixed carbon is marked off at the bottom of the chart, and the distance in miles on the sides. The per cent. of fixed carbon found in the coals of a certain locality with the distance in miles of the locality from an initial or starting point, give the means of platting the curves or diagrams. No. 1 shows the decrease in value of coals in passing from Columbus on the south to Cloud county on the north. No. 2 shows the decrease in value of coals in passing from Pittsburg on the east to Cloud county on the west.



DIAGRAMS SHOWING DECREASE IN PER CENT. OF CALORIFIC POWER OF COALS OF THE STATE.

The per cent. of calorific power, or the number of pounds of water evaporated per pound of coal burned, is marked off at the bottom of the chart, the distance, in miles, of the locality on the sides, from an initial or starting point, give the means of platting the curves or diagrams. No. 1 shows the decrease in heat producing value of coals in passing from Columbus on the south to Leavenworth on the north. No. 2 shows the decrease in value in passing from Pittsburg on the east to Osage City on the west.

MINE OF CENTRAL COAL AND COKE COMPANY,
NEAR WEIR CITY.

(Photographed by Crane, 1897.)

COKING OVEN, WEIR CITY.

(Photographed by Crane, 1897.)

DRIFT SLOPE MINE, WEIR CITY.

(Photographed by Crane, 1897.)

COKE WASHING PLANT, WEIR CITY.

(Photographed by Crane, 1897.)

ENTRANCE TO DRIFT SLOPE MINE, WEIR CITY.

(SEE PLATE LVI.)

(Photographed by Crane, 1897.)

SMALL POWER SHAFT NEAR PITTSBURG.

(Photographed by Crane, 1897.)

FOLDING OF STRATA AS SEEN IN CLAY PITS, AT NESCH BRICK WORKS, PITTSBURG.

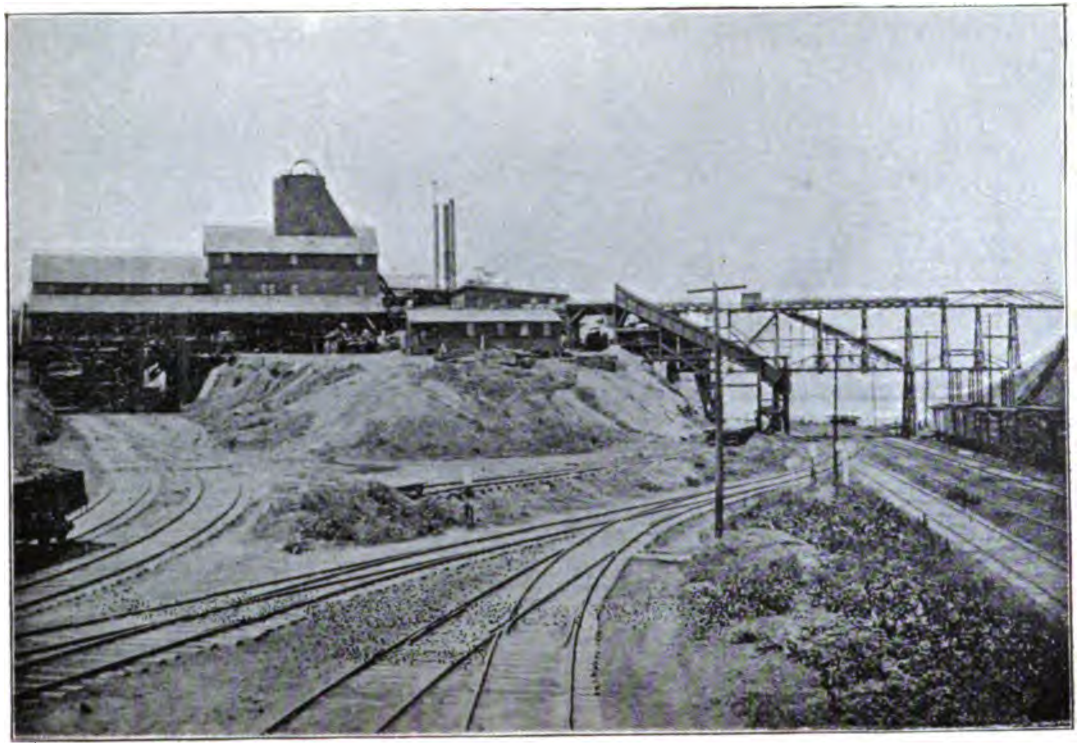
(Photographed by Crane, 1897.)

M. K. & T. COAL MINE, AT MINERAL CITY.
(Photographed by Crane, 1897.)

HOISTING ENGINE AND DRUM, M. K. & T. MINE, MINERAL CITY.

(Photographed by Crane, 1897.)

STATE MINE, LANSING.
(Photographed by Crane, 1897.)



HOME-RIVERSIDE COAL MINING COMPANY, PLANT No. 1, LEAVENWORTH.

HOME-RIVERSIDE COAL MINING COMPANY, PLANT No. 2, LEAVENWORTH.

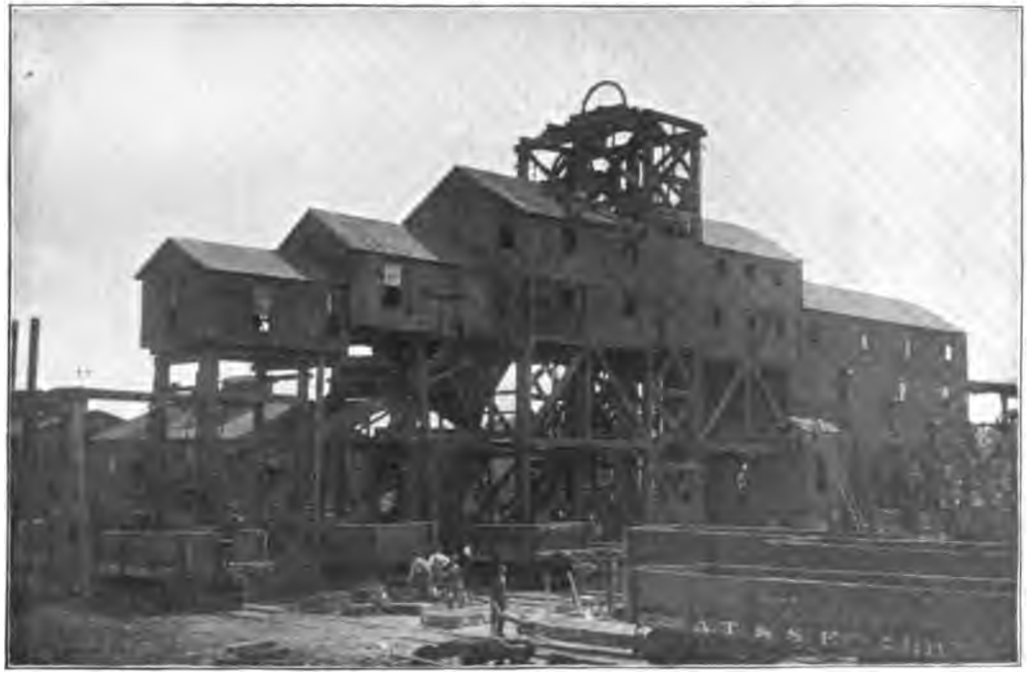
HOME-RIVERSIDE COAL MINING COMPANY, PLANT No. 2, LEAVENWORTH.

(Photographed by Crane, 1897.)

LEAVENWORTH COAL COMPANY'S MINE, LEAVENWORTH.

(Photographed by Crane, 1897.)

MINE OF WESTERN COAL AND MINING COMPANY, NEAR FLEMING.



MINE No. 5 OF MOUNT CARMEL COAL COMPANY, CHICOPEE.

OUTPUT AND COMMERCE OF KANSAS COAL.

Production.

The production of coal depends largely upon the geographic position of the area from which the coal is mined. The central bituminons coal fields, of which Kansas forms no small part, occupy a position midway between the coal fields of Colorado, Dakota, Wyoming, and New Mexico on the west; of Ohio, Illinois, Indiana, Kentucky, and Pennsylvania on the east; and of Alabama and Tennessee on the southeast. There is, however, an area barren of coal extending around this central area, thus isolating it from the surrounding coal fields.

The western portion of this coalless area is also destitute of any material which may be used as a substitute for coal, while to the east, north, and south the area is bountifully supplied with timber, the effect of which upon the coal industry is apparent as wood is so largely used for fuel. The coal deposits of Kansas, Iowa, Missouri, Texas, and the Indian Territory must be the coal supply of the coal barren area to the west and, to a limited extent, to the north, east, and south. The competition of eastern coal is rather severely felt, due to the cheaper transportation by land and water from the east and the higher rates in the west. The foreign market of the Kansas coal is thus principally to the westward, although no small amount is sent east, on account of the excellent heat producing qualities of this coal.

The home market at present consumes a large per cent. of the yield and with the prospective rapid development of the resources of the state this market promises to become a most important factor in the further development of the coal industry and the maintenance of a large output from the mines of the state.

From data in possession of the Survey, obtained principally

from prospecting drill holes and deep well borings for gas and oil, it is found that in the Coal Measures and more especially in the Cherokee shales, a large number of coal strata exist—as high as ten to one drill hole in places—a large per cent. of which are workable, but are not mined at present owing to the low price of coal. There is, however, no doubt that in time these thinner coal strata will be worked. But as long as the coal lands are held for grazing and agricultural purposes and only small mines are operated by individuals rather than large mines by larger companies, there is not much prospect of a rapid extension of mining operations in these new fields. The output will not materially increase as long as the price of coal is held down by the more available and thicker beds elsewhere. If, however, the price should rise a few cents per bushel, there would be opened immediately a large number of mines in which operations are not now contemplated because of the low price of coal.

The principal coal producers operating in Kansas are:

The Cherokee and Pittsburg Coal Mining Company.
The Western Coal Mining Company.
The Kansas and Texas Coal Company.
The Central Coal and Coke Company.
The Pittsburg and Midway Coal Company.
The Wear Coal Company.
The Fuller Coal Mining Company.
The Arnott and Lanyon Company.
The Mount Carmel Coal Company.
The J. H. Durkee Coal Company.
The Osage Carbon Company.
The Southwestern Coal and Improvement Company.
The Western Fuel Company.
The State Mine (Lansing).
The Home-Riverside Mining Company.
The Leavenworth Coal Company.

Besides the ones above mentioned there are a large number of smaller steam and horse power shafts run very irregularly by private parties.

TABLE VIII.—Showing Total Coal Production of the State, by Counties, since 1885.

Figures previous to 1897 are taken from the Eighteenth Annual Report of the U. S. Geological Survey, Mineral Resources, Part V, page 526.

(SHORT TONS.)

County.	1885.	1886.	1887.	1888.	1889.	1890.	1891.	1892.	1893.	1894.	1895.	1896.	1897.
Atchison	....	....	....	....	....	....	....	....	....	3,500	1,200	4,592	5,152
Cherokee	371,930	375,000	385,262	450,000	549,873	724,861	832,289	825,531	697,521	948,142	918,944	985,132	1,061,409
Coffey	....	....	....	....	18,272	12,200	1,218	3,664	1,720	475	120	....	10,000
Crawford	221,741	250,000	298,049	425,000	827,159	900,464	997,759	1,309,246	1,195,868	1,554,253	1,354,614	1,271,434	1,590,621
Franklin	14,518	15,000	18,080	25,000	37,771	9,045	10,277	11,150	11,768	17,418	17,047	12,861	6,452
Labette	....	....	....	....	2,541	4,000	800	800	800	440	250	600	2,000
Leavenworth	120,561	160,000	195,480	210,000	245,616	319,866	380,142	330,166	309,237	395,967	259,060	284,700	367,141
Linn	5,556	8,900	12,400	17,500	25,345	10,474	38,934	43,913	46,464	25,867	14,051	14,534	26,775
Osage	370,552	380,000	393,608	415,000	446,018	179,012	355,286	372,806	279,168	322,189	241,584	190,948	181,857
Small mines	107,199	211,100	294,000	307,500	68,448	100,000	100,000	110,000	110,000	120,000	120,000	120,000	40,399
Totals	1,212,057	1,400,000	1,596,879	1,850,000	2,221,043	2,259,922	2,716,705	3,007,276	2,652,546	3,388,251	2,926,870	2,884,801	3,291,806

Value of Coal.

As the value of any product cannot be estimated until the quantity is known, so not even an approximate estimate can be placed upon the coal deposits of a given area until the quantity of coal lying therein is determined. The determination of the amount of Kansas coal is exceedingly difficult, due to the variability of the thickness of the coal strata.

It is known, however, that a stratum of coal 1 foot in thickness and an acre in areal extent will produce approximately 1,700 tons. Probably one-third of this amount will be left in the mine as waste, supports to the roof, etc., leaving about 1,200 tons of available coal. With a 2½ foot stratum of coal (an approximate average for the coals worked) the production per acre would amount to 3,000 tons. A stratum of coal 2½ feet thick would produce per square mile 1,920,000 tons. The output for 1897, was 3,290,000 tons, therefore the area of about two square miles is exhausted per year. About one-fourth, or 20,000 square miles, of Kansas lies within the Coal Measures. If one-fifth of this area can be taken as a fair estimate of the area underlaid with workable coal, there would be 4,000 square miles of coal producing territory. It would, therefore, at the present rate of output, take 2,000 years to exhaust the coal deposits of the Kansas Coal Measures. But as the output must correspondingly increase with the steadily increasing demand it will be seen that the most careful calculation can be nothing more than approximations at best.

Taking the highest and lowest prices paid for coal in Kansas since 1889, which were $2.18 and 97 cents,— as given in the U. S. Mineral Resources, 1886 and 1887, Part V, page 527 — an acre of coal 2½ feet thick would have maximum and minimum values of $6,540 and $2,910. The value of the coal taken from a square mile would lie between $4,185,600 and $1,862,400.

The five principal means of consumption of the Kansas coals are, railways, manufactures, domestic use, gas works, and coking establishments. These are given in the relative order of importance. The railways are the greatest consumers. This class along with the manufactures employ the coal for steam-

TABLE IX.—SHOWING AVERAGE PRICES FOR KANSAS COAL SINCE 1889, BY COUNTIES PRODUCING 10,000 TONS OR OVER.

From U. S. Geological Report on Mineral Resources, 1897, Part V, page 527.

COUNTY.	1889.	1890.	1891.	1892.	1893.	1894.	1895.	1896.	1897.
Cherokee	$1 20	$1 22	$1 19	$1 22	$1 15	$1 13	$1 22	$1 23	$1 30
Crawford	1 20	1 24	1 09	1 08	1 10	1 07	1 02	97	1 30
Franklin	2 18	2 00	1 90	1 85	1 84	1 88	1 84	1 80	....
Leavenworth	1 69	1 60	1 40	1 60	1 55	1 49	1 49	1 30	1 30
Linn	1 32	1 34	1 23	1 27	1 22	1 20	1 10	97	....
Osage	2 03	1 35	2 04	2 04	1 85	1 89	1 45	1 65	1 75
The State	$1 48	$1 30	$1.31	$1 31¼	$1 27	$1 23	$1 20	$1 15	....

producing purposes. As steam producers Kansas coals rank high, especially those of the Cherokee shales, mined in Cherokee, Crawford, Bourbon, and Leavenworth counties. The evaporative power of some coals from Crawford and Cherokee counties reaches as high as 15.5 pounds of water per pound of coal, which is very close to that of the United States standard, the Indiana block, of Clay county. Nearly all of the coals are good for domestic purposes, some, however, much better than others. The Bunker Hill coal and the Fort Scott "rusty" or "red" are much sought after for domestic use.

The Cherokee coal, that is the coal from Cherokee and Crawford counties, is the best gas producer in the state. It cokes quite readily and the expense of purifying it from sulphur is slight. This coal is used extensively for coking in Cherokee and Crawford counties, where are located several coal washing establishments in connection with coking ovens. The coke is used in the smelters, but the demand for coke has declined of late, especially in the vicinity of Weir City since it has been found that the slacked coal which can be obtained in close proximity to the smelters by stripping and at a very low figure makes a very good fuel for smelting purposes.

The two following tables give the statistics of the coke industry in Kansas for a number of years preceding and including 1896.

TABLE X.—SHOWING STATISTICS OF THE MANUFACTURE OF COKE IN KANSAS FROM 1880 TO 1896.

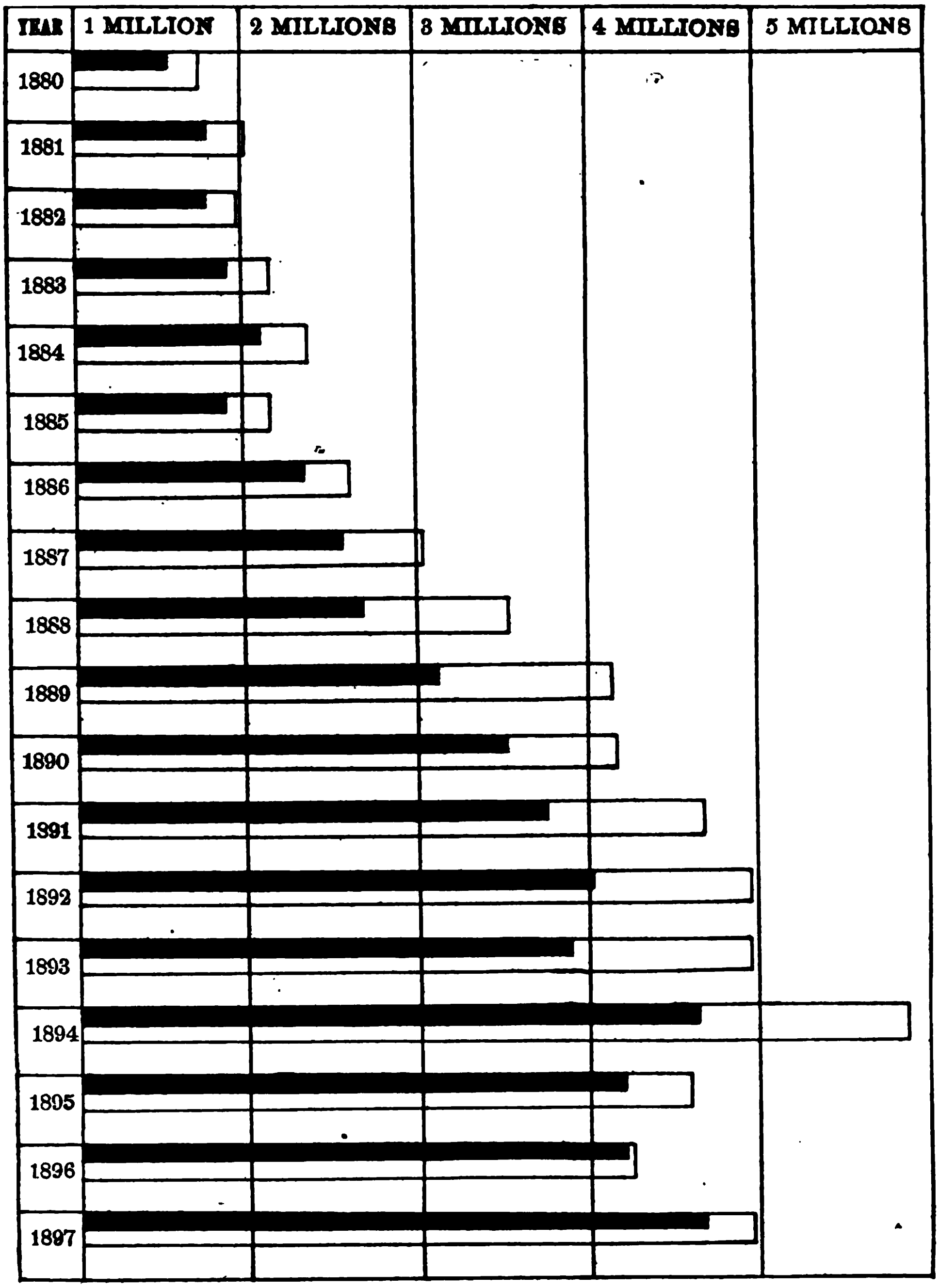
From Eighteenth Ann. Rep., 1896-'97, U. S. Geol. Surv., Min. Res., part V, page 703.

YEAR.	Establishments	Ovens		Coal used.	Coke produced.	Total value of coke at ovens.	Value of coke at ovens, per ton.	Yield of coal in coke.
		Built.	Building.					
				Short tons.	*Short tons.*			*Per ct.*
1880	2	6	....	4,800	3,070	$6,000	$1.95	64
1881	3	15	....	8,800	5,670	10,200	1.80	64.4
1882	3	20	....	9,200	6,080	11,460	1.70	65
1883	4	23	....	13,400	8,430	16,560	1.96	62.9
1884	4	23	....	11,500	7,190	14,580	2.02	62.5
1885	4	23	....	15,000	8,050	13,255	1.65	53.7
1886	4	36	....	23,062	12,493	19,204	1.54	54.2
1887	4	39	....	27,604	14,950	28,575	1.91	54
1888	6	58	....	24,934	14,831	29,073	1.96	59
1889	6	68	....	21,600	13,910	26,593	1.91	61
1890	7	68	....	21,809	12,311	29,116	2.37	56
1891	6	72	....	27,181	14,174	33,296	2.35	52
1892	6	75	....	15,437	9,132	19,906	2.18	59.2
1893	6	75	0	13,645	8,565	18,640	2.18	62.8
1894	6	61	0	13,288	8,439	15,660	1.855	63.5
1895	5	55	0	8,424	5,287	11,289	2.14	62.8
1896	6	55	0	8,940	4,785	8,676	1.813	53.5

TABLE XI.—SHOWING CHARACTER OF COAL USED IN THE MANUFACTURE OF COKE IN KANSAS, 1890 TO 1896.

From Eighteenth Ann. Rep., 1896-'97, U. S. Geol. Surv., Min. Res., part V, page 704.

YEAR.	Run of mine.		Slack.		Total.
	Unwashed.	Washed.	Unwashed.	Washed.	
	Short tons.	*Short tons.*	*Short tons.*	*Short tons.*	*Short tons.*
1890	0	0	19,619	2,190	21,809
1891	0	0	27,181	0	27,181
1892	0	0	15,437	0	15,437
1893	0	0	12,445	1,200	13,645
1894	0	0	13,288	0	13,288
1895	0	0	8,424	0	8,424
1896	0	0	8,940	0	8,940



ANNUAL OUTPUT AND VALUE OF COAL,
FROM 1880 TO 1897, INCLUSIVE.

The output is represented by the solid black, and value by the open spaces.

MINE DIRECTORY.

BY W. R. CRANE.

It has been thought advisable to tabulate that part of the data collected for the present report, that can be given in a brief form, and that may be of value to those seeking information regarding the mines and who do not have time for more extended investigation.

The data given in this table have been taken from the field note books and in most cases the authenticity of the same has been verified by the writer, but in some cases this was impossible, namely, in regard to previous conditions of the mine, nature of the roof and floor in parts of the mine long since unworked and therefore closed or filled with water, in regard to various formations met with but obscure and covered up when visited, gas, and fossils, etc. In such cases the statements of the mine operators have been taken, which in most cases were unprejudiced.

Table XII following gives the location and depth of mines, thickness of coal strata, grades of coal produced, capacity of mines, and machiney employed in the mines visited.

TABLE XII.—LOCATION OF MINES AND SYSTEMS OF MINING.

Index No.	Mine No.	Operators.	Location.	When visited.	Systems of mining.
1	5	Wear Coal Co.	2½ miles northeast of Pittsburg	July 26	Room and pillar.
2	....	Arnott & Lanyon Coal Co.	2 miles northeast of Pittsburg	" 26	" "
3	....	E. C. Sheldon	2 miles north and one-fourth mile west of Pittsburg		
4	1	Cherokee & Pittsburg Coal and Mining Co	Frontenac	July 26	Room and pillar.
				" 26	" "
5	2	Cherokee & Pittsburg Coal and Mining Co	"	" 27	" "
6	4	Cherokee & Pittsburg Coal and Mining o	Chicopee	" 27	" "
7	2	Wear Coal Co.	Kirkwood	" 27	" "
8	9	Central Coal and Coke Co.	Pacific	" 29	" "
9	37	K. & T. Coal Co.	Litchfield	" 29	" "
10	4	Pittsburg & Midway Coal Co	Midway	Aug. 1	" "
11	...	" " "	"	" 1	" "
12	3	Southwestern Coal Mining Co.	Cornell	" 1	" "
13	5	Western Coal Mining Co.	Yale	" 1	" "
14	4	" " "	"	" 1	" "
15	..	Dick Wilson	Just north Pittsburg	" 3	" "
16	6	Wear Coal Co.	" "	" 5	" "
17	20	K. & T. Coal Co.	Near Chicopee	" 6	" "
18	....	Jenning Coal Co.	One-half mile west of Pittsburg	" 6	" "
19	6	Mo. Pac. Ry. Coal Co.	North of Yale	" 6	" "
20	3	Western Coal Mining Co.	Fleming	" 8	" "
21	2	" " "	"	" 8	" "
22	3	J. H. Durkee Coal Co.	Weir City	" 8	" "
23	3	Hamilton & Grant	"	" 8	" "
24	47	K. & T. Coal Co.	North of Weir City	" 9	" "
25	23	" "	" "	" 9	" "
26	18	" "	" "	" 10	" "
27	....	John Bennett	Weir City	" 10	" "
28	2	Hamilton & Braidwood	"	" 10	" "
29	.	" "	"	" 11	" "
30	5	Central Coal and Coke Co.	"	" 11	" "
31	1	Durkee Coal Co.	"	" 11	" "
32	5	John Bennett	"	" 11	" "
33	8	Central Coal and Coke Co.	"	" 12	" "
34	2	Weir Bros. Coal Co.	"	" 13	" "
35	6	Central Coal and Coke Co.	"	" 13	" "
36	3	Davis Coal Co	Cherokee	" 13	" "
37	7	Central Coal and Coke Co.	Scammon	" 15	" "
38	3-2	Durkee Coal Co.	"	" 15	" "
39	4	" "	"	" 15	" "
40	6	Southwestern Coal and Improvement Co.	Mineral City	" 16	" "

TABLE XII—continued. DEPTH OF MINES, GRADES OF COAL PRODUCED, AND CONDITION OF STRATA.

Index No.	Depth of mine.	Thickness of coal stratum.	Capacity per day in tons and cars.	Grades of coal.				Gas.	Black jack.	Fossils.
1	35 feet	2 feet 4 in. to 3 feet,	400 tons.	Lump	Egg.	Nut.	Slack	A trace		None.
2	55 "	2 feet 5 in. to 3 feet,	25 to 30 cars	"	"		"		A trace	"
3	Unknown	Unknown.	Unknown		"	Nut.			"	"
4	112 feet	3 fe t 2 to 4 in.	1200 tons.	Lump	"	"				"
5	115 "	3 feet	800 "	"	"	"	Slack	A trace		Traces.
6	45 "	3½ feet	Unknown	"	"	"		"	A trace	A few.
7	35 "	3 feet 3 to 4 in	40 to 50 cars	"	"	"		"		
8	100 "	3½ feet.	Unknown	"	"	"		A trifle		Traces.
9	35 "	3 to 3½ feet	500 cars.	"	"	"		"		
10	70 "	3 to 4 feet	35 "	"	"	"				Quite a number.
11	35 "	3½ to 4 feet	Unknown	"	"	"	Slack		Considerable	Traces.
12	60 "	2 feet 10 in. to 3 ft	400 tons.	"	"	"			"	"
13	100 "	2 feet 6 to 8 in.	650 to 700 tons,	"	"	"		A trace	A trace	
14	72 "	3 feet.	450 to 500 "	"	"	"		"	"	
15	40 "	3 feet 2 to 6 in.	10 to 15 "		"	"				
16	50 "	3 to 3½ feet	20 to 25 "	Lump	"	"			A trace	A few.
17	60 "	3½ feet.	50 cars	"	"	"		A trace	"	"
18	25 "	3 feet 2 in. to 4 feet,	20 tons.	"	"	"			"	"
19	100 "	3½ to 4 feet	Unknown		"	"				Traces.
20	100 "	3 feet 3 in	60 tons.	Lump	"	"	Slack	Good deal	Quite abundant	"
21	100 "	3 feet 2 to 4 in.	Unknown	"	"	"		" "	" "	"
22	50 "	3½ feet.	50 cars	"	"	"			Very little	"
23	80 "	3½ feet.	Unknown	"	"	"			A great deal.	Animal forms.
24	30 "	3½ to 4 feet	1150 tons.	"	"	"		A trace	Very little.	Traces.
25	42 "	3 feet 6 to 8 in.	600 "	"	"	"		"	" "	"
26	76 "	3½ feet.	1300 "	"	"	"			Quite abundant.	"
27	Unknown	Closed	Unknown	Closed	Closed	Closed	Closed			"
28	73 feet	3 feet 3 to 6 in.	1600 tons.	Lump	Egg.	Nut.	Slack	A trace	6 inches	"
29	80 "	3½ feet.	Unknown	"	"	"	"		6 "	"
30	60 "	3½ feet.	"	"	"	"				"
31	50 "	3 feet 8 in	600 to 700 tons.	"	"	"		A trace	Very little	None.
32	55 "	3½ feet.	Unknown	"	"	"				
33	75 "	3 feet 4 to 6 in.	55 cars	"	"	"	Slack		None	None.
34	96 "	3 feet 4 to 8 in.	Unknown	"	"	"		A little	Very little	Traces.
35	72 "	3 feet 8 in	900 tons.	"	"	"	Slack		" "	"
36	150 "	3 feet 6 to 8 in.	Unknown	"	"	"			" "	"
37	90 "	3½ feet	800 tons.	"	"	"			None	
38	67 "	4 feet.	160 "	"	"	"			2 to 3 inches	Quite abundant.
39	Unknown	Unknown.	Unknown	"	"	"				Traces.
40	125 feet	3 feet 8 to 10 in.	15 cars.	"	"	"		A good deal	Quite abundant	"

Index No.	No. of cages.	Form of dump.	Scales. No.	Scales. Manufacturers.	Railroad connections.	Screens.	Condition of mine.	Screening Engine. No.	Dimensions.	Horse-power	Manufacturers.
1	2	Hand	2		K. C. Ft. S. & M.	Parallel bars & revolv. screens,	Wet	1	Unknown,	Unkn.	Kimball, Lawrence, Kan.
2		"	2		A. T. & S. F.	1 set par. bars & 2 sets rev. sc.	Dry	1	"	"	Chandler & Taylor, St. Louis.
3		"			"	Parallel bars.	Wet				
4	2	Automatic	1		"	2 sets parallel bars	"	1	Unknown,	35	Morris M. W., Baldwinsville, Mo.
5	2	Hand	1		"	2 " "	"	1	"	35	" " "
6	2	Automatic	2		"	2 " "	"				
7	2	Hamilton's autom.	1		Unknown	1 set par. bars & 2 sets rev. sc.	"	1	Unknown,	30	Ottumwa Iron Works, Iowa.
8	2	Hand	2	Monarch Standard,	"	1 " " 2 "	"	1	"	25	Atlas Eng. Works, Indianapolis.
9	2	"	1	Fairbanks	A. T. & S. F.	Unknown	Unknown	1	"	Unkn	G. S. Wormer & Son, St. Louis.
10	2	"	2	Fairbanks track, Howe top.	"	2 sets par. bars & 2 sets rev. sc.	Not very wet,	1	"	"	Common steam engine.
11	2	Automatic	2	" "	Unknown	4 sets parallel bars	" "	1	"	"	Unknown.
12	2	Hand	2	" "	Mo. Pac.	Unknown	" "	1	"	20	Wm. Jordan, Lexington, Mo.
13	2	"	2	" "	"	1 set rev sc. & 2 sets par. bars	" "	1	"	Unkn.	M. Nagle, Erie, Pa.
14	2	"	2	Fairbanks track, A. B. Pearson top.	"	2 sets parallel bars	Dry				
15	2	"	1	Unknown	"	1 " "	Unknown				
16	2	"	1	Monarch	None	1 " "	"				
17	2	Bond's automatic	2	Fairbanks track, Monarch top.	St. L. & S. F.	Unknown	"	1	Unknown,	12	G. S. Wormer & Son, St. Louis.
18	2	Hand	1	Howe	" "	2 sets parallel bars	"				
19	2	"	1	Fairbanks	Mo. Pac.	2 " "	"				
20	2	"	2	Howe	"	2 " "	"	1	10x16 in.	Unkn.	Houston, S. & G., Cincinnati.
21	2	"	2	"	"	2 " "	"	1	Unknown,	10	M. Nagle, Erie, Pa.
22	2	"	2	"	"	2 " "	Wet	1	"	10	" "
23	2	"	1	Monarch	K. C. Ft. S. & M.	Parallel bars & revolv. screens,	Not very wet,	1	"	40	Unknown.
24	2	Bennett's aut'm'tic,	2	Fairbanks track, Monarch top.	" "	" " " "	Wet	1	10x16 in.	Unkn.	Joplin Machine Works No. 50, Joplin, Mo.
25	2	" "	2	" "	" "	" " " "	Not very wet,				
26	2	" "	2	Fairbanks track, Strait top.	" "	" " " "	Wet	1	Unknown,	Unkn.	Old, unknown.
27		" "			None	Unknown	Quite wet				
28	2	Hand	2	Howe	K. C. Ft. S. & M.	1 set par. bars & 2 sets rev. sc.	Unknown	1	8x10 in.	Unkn.	Erie Engine Works, Erie, Pa.
29		"	2	"	Unknown	1 " " 2 "	Not very wet.	Unkn.	Unknown,	"	Unknown.
30	2	"	2	Fairbanks track, Monarch top.	K. C. Ft. S. & M.	2 " " 2 "	Wet	1	6x8 in.	"	Joplin Machine Works, Joplin, Mo.
31	2	Griffith's autom'tic,	2	Fairbanks track, Howe top.	" "	Parallel bars & rotat. screens	"	1	7x8 in.	"	Keystone Iron Works, Kan. City.
32	2	Hand	1	Fairbanks	Unknown	Unknown	Quite wet	1	12x22 in.	"	A. B. Bowman, St. Louis.
33	2	"	2	"	K. C. Ft. S. & M.	2 sets par. bars & 2 sets rev. sc.	Unknown	1	8x10 in.	"	Atlas Eng. Works, Indianapolis.
34	2	"	2	Fairbanks track, Monarch top.	St. L. & S. F.	1 " " 1 "	Wet	1			Threshing engine.
35	2	"	2	Fairbanks	K. C. Ft. S. & M.	2 " " 2 "	Dry				
36	2	"	1	"	" "	Unknown	Wet				
37	2	"	2	"	" "	Parallel bars & revolv. screens,	"	1	9x14 in.	Unkn.	Atlas Eng. Works, Indianapolis.
38	2	"	2	Fairbanks track, Howe top.	" "	2 sets par. bars & 2 sets rev. sc.	Not very wet,	1	Unknown,	35	M. Leckie, Joplin, Mo.
39	2	"	1	Monarch	" "	2 " " 2 "	Very wet	1	"	Unkn.	Unknown.
40	2	"	2	Fairbanks track, A. B. Pearson top.	M. K. & T.	2 " " 1 "	"	1	8x12 in.	"	Erie Engine Works, Erie, Pa.

TABLE XII—continued. MINING MACHINERY—*continued.*

Index No.	Boilers.				Boiler Pump.			Mine Pump.		
	No.	Dimensions.	Horse-power.	Manufacturers.	No.	Dimensions.	Manufacturers.	No.	Dimensions.	Manufacturers.
1	1	Unknown	Unkn.	Keystone Boiler Co.						
2	2	"	"	John O'Brien, St. Louis, Mo.						
3										
4	3	Unknown	Unkn.	Santa Fe Boiler Works	1	Hooker, No. 12, unkn.	Hooker & Codell, St. L.,			
5	3	"	"	" "	1	" " "	" " "			
6	2	"	(60+40)100	John Moler & Son, Chicago, Ill				1	6 in. suct., 5 in. dis.	Hammeron, No. 12.
7	2	"	Unkn.	Ottumwa Iron W'ks, Ottumwa, Iowa,				1	Unknown	" "
8	2	48 in. x 24 ft.	"	Keystone Iron Works, Kansas City				1	2 inch discharge	Duplex.
9	2	Unknown	"	Brunnell & Co., Dayton, Ohio	1	Knowles, No. 4, unkn.	Knowles Manuf'g Co., Warren, Mass.			
10	2	Unknown	(40+40)80	Unknown	1	Unknown	Canton Pump Co., Canton, Ohio.			Injector.
11	2	Unknown	Unkn.	Unknown	1	Unknown	Canton Pump Co.			
12	2	48 in. x 25 ft.	40	G. Leach, Kansas City, Mo.; Mackenally, Pittsburg, Kan.				1	2 in. suct., 1½ in. dis.	H. R. Worthington, St. Louis.
13	3	64 in. x 28 ft.	Unkn.	J. O'Brien Boiler Works, St. Louis				2	Unknown	Worthington & Knowles.
14	2	48 in. x 20 ft.	"	" " "		Nos. 2 and 4	Dodge injector			
15										
16										
17	2	44 in. x 28 ft. 44 in. x 28 ft.	Unkn.	M. Nagle, St. Louis; Springfield Car and Foundry Co.	1	Unknown	H. R. Worthington, New York.	4	3 in. suct., 4 in. dis.	1 Knowles, 3 belt pumps.
18								None.		
19	2	Unknown	Unkn.	Unknown						
20	2	42 in. x 24 ft.	"	"				1	3½ in. suct., 3 in. dis.	Davidson & Co., New York.
21	2	Unknown	"	Ft. Scott Foundry, Ft. Scott, Kan.	1	Unknown	Unknown	2	3 in. suct., 2 in. dis.	H. R. Worthington, St. Louis.
22	1	50 in. x 20 ft.	"	Chandler & Taylor	1	Nos. 5, 4½, 2¾, & 4½.	Canton Pump Co.	1		Home-made.
23	1	Unknown	"	Pittsburg Fo'dry Co., Pittsb'g, Kan.						Hoist water with barrel.
24	2	48 in. x 24 ft. 44 in. x 22 ft.	"	Unknown				1	2½ in. suct., 2 in. dis.	Hooker Pump Co., No. 6½.
25	2	36 in. x 18 ft. 48 in. x 26 ft.	Unkn.	Made at Springfield, Mo.				2	2½ in. suct., 2 in. dis. 7½ in. suct., 6 in. dis.	1 Perkins; 1 Cook, St. Louis.
26	2	46 in. x 26 ft. 46 in. x 20 ft.	Unkn.	Joplin Foundry, Joplin, Mo.				2	2½ in. suct., 2 in. dis.	Hooker, No. 7; Knowles.
27	Unkn.	Unknown	Unkn.	Unknown						
28	2	44 in. x 28 ft. 36 in. x 28 ft.	"	McNally, Pittsburg, Kan.; Keystone Iron Works, Kansas City, Mo.				1	4 in. suct., 3 in. dis.	Cammeron, No. 7.
29	Unkn.	Unknown	Unkn.	Unknown				1	Unknown	Unknown.
30					1	2 in. suct., 1½ in. dis.	Fairbanks, Morse & Co.,	2	2 in. suct., 1½ in. dis.	Fairbanks, Morse & Co.
31	1	42 in. x 20 ft.	Unkn.	Unknown	1	1¼ in. suct., 1 in. dis.	The Dean	2	3 in. suct., 2 in. dis.	Duplex; Miller, Canton, Ohio.
32	2	Unknown	"	John O'Brien Boiler Works				1		Home-made.
33	3	40 in. x 20 ft. 36 in. x 18 ft.	"	English, Morse & Co., Kansas City	1	4½ in. suct., 3½ in. dis.	Fairbanks, No. 858	1	3½ in. suct., 3 in. dis.	Dayton Pump Co., Dayton, Ohio.
34	1	48 in. x 24 ft.	Unkn.	Unknown						Water raised by barrel.
35	2	44 in. x 24 ft.	"	Joplin Machine Works, Joplin, Mo.,	1	2 in. suct., 1½ in. dis	Pullings, No. 3	1	3 in. suct., 2½ in. dis.	Knowles, No. 3.
36				Horse-power mine.						
37	2	44 in. x 20 ft.	Unkn.	English, Morse & Co., Kansas City				2	3.4 in. suct., 3 in. dis.	Fairbanks & Co., Dayton P. Co.
38	1	40 in. x 20 ft.	"	Brownville, Ft. Scott, Kan.	1	Unknown	Rue's "Little Giant" injector, New York.	2	3 in. suct., 2 in. dis.	Knowles, Duplex; Pulsometer Pump Co., Sibley, Mo.
39	Unkn.	Unknown	Unkn.	Unknown				1	Unknown	Unknown.
40	1	40 in. x 22 ft.	"	Rohern Bros. Boiler Co., St. Louis	1	Unknown	Injector	2	6 in. suct., 4 in. dis.	Fairbanks, Morse & Co.

TABLE XII—continued. MINING MACHINERY—*continued.*

Index No.	Hoisting Drum.					Hoisting Engine.				
	Single.	Double.	Side gear.	Center gear.	Dimensions.	No.	Cylinders.	Dimensions.	Horse-power.	Manufacturers.
1	Single..		S. gear..			1	2	Unknown,	10 each,	Wm. Ellison & Son. St. Louis, Mo.
2						1	2	"	30 "	Griffiths & Wedge, Zanesville, Ohio.
3										
4						1	2	Unknown,	50 each,	Wyoming Valley Mfg. Company, Wilkesbarre, Pa.
5						1	2	"	50 "	" " " " " "
6						1	Unkn.	"	Unkn...	The Great Western Mfg. Co., Leavenworth, Kan.
7						1	2	"	80 each,	Ottumwa Iron Works, Ottumwa, Iowa.
8		Double,		C. gear..		1	2	"	70 "	Keystone Iron Works, Kansas City, Mo.
9										
10		Double,		C. gear..	6 feet	1	2	Unknown,	16 each,	Ottumwa Iron Works, Ottumwa, Iowa.
11		"	Unkn...	Unkn...	6 "	1	2	12x16 in...	Unkn...	Riverside Iron Works, Kansas City, Mo.
12	Single..		S gear..		4½x6 feet	1	1	10x16 in...	" ...	" " " "
13		Double,	Unkn...	Unkn...	4½x10 feet	1	1	Unknown,	20	" " " "
14		"	" ...	" ...	5 feet	1	2	10x16 in...	19 each,	" " " "
15					Horse-power,					
16										Threshing engine.
17	Single..		Unkn...	Unkn...	4½ feet.	1	2	Unknown,	20 each,	Springfield Car and Foundry Co, Springfield, Mo.
18					Horse-power,					Horse-power mine.
19		Double,	S. gear..		5 feet.	1	2	Unknown,	30 each,	Wm. Ellison, St. Louis, Mo.
20		"	Unkn...	Unkn...	4½ feet	1	2	"	Unkn...	Keystone Iron Works, Kansas City, Mo.
21						1	2	10x16 in...	40 each,	" " " "
22	Single..		Unkn...	Unkn...	4 feet	1	1	13x16 in...	70	Chandler & Taylor, engine manufacturers.
23		Double,	" ...	" ...	3 "	1	1	Unknown,	40	Unknown.
24	Single..		" ...	" ...	3x4½ feet	1	2	"	40 each,	Made at Springfield, Mo.
25	" ..		" ...	" ...	4½x5 "	1	2	8x10 in...	16 "	G. S. Wormer & Son, Chicago, Ill.
26						1	2	10x10 in...	25 "	Ledgewood.
27		Double,	Unkn...	Unkn...	5 feet					
28						1	2	10x16 in...	16 each,	Keystone Iron Works, Kansas City, Mo.
29		Double,	Unkn...	Unkn...	5x6 feet	1	2	12x22 in...	Unkn...	Unknown.
30	Single..		" ...	" ...	4x6 "	1	2	12x16 in...	40 each,	M. Leckie, Joplin, Mo.
31						1	2	10x16 in...	15 "	Keystone Iron Works, Kansas City, Mo.
32		Double,		C. gear..	4 feet	1	1	12x22 in...	Unkn...	A. B. Bowman, St. Louis, Mo.
33		"		" ..	4 "	1	2	10x16 in...	18 each,	Unknown.
34	Single..		Unkn...	Unkn...	5x6 feet	1	2	9x17 in...	Unkn...	Keystone Iron Works, Kansas City, Mo.
35						1	2	12x18 in...	25 each,	Unknown.
36		Double,	Unkn...	Unkn...	4x8 feet					Horse-power mine.
37		"		C. gear..	4 feet.	1	1	14x24 in...	Unkn...	Riverside Iron Works, Kansas City, Mo.
38	Unkn...	Unkn...	Unkn...	Unkn...	Unknown	1	2	10x12 in...	45 each,	Ottumwa Iron Works, Ottumwa, Iowa.
39		Double,	" ...	" ...	"					
40		"	" ...	" ...	5½ feet	1	1	16x30 in...	60	Litchfield Car and Machine Co., Litchfield, Ill.

TABLE XII—concluded. MINING MACHINERY—*concluded.*

Index No.	Fans.		Fan Engine.		
	Dimensions.	No.	No.	Horse-power.	Manufacturers.
1	....	....	....	....	
2	12 feet.......	1	1	15	Unknown.
3	....	....	....	....	
4	....	....	1	Unknown,	William E. Cole, Washington, Ind.
5	....	....	1	"	" " " "
6	12 feet.......	1	1	"	" " " "
7	12 "	1	1	"	Unknown.
8	14 "	1	....	....	
9	12 "	1	1	Unknown,	Crawford & McCrimmon, Brazil, Ind.
10	3 x 12 "	1	1	"	" " " "
11	12 "	1	1	"	" " " "
12	10 "	1	1	16	" " " "
13	16 "	1	1	Unknown,	" " " "
14	12 "	1	1	12	" " " "
15	....	....	....	....	No fans.
16	....	....	....	....	"
17	12 feet......	1	1	Unknown,	Crawford & McCrimmon, Brazil, Ind.
18	....	....	....	....	No fans.
19	12 feet.	1	1	Unknown,	William Ellison, St. Louis, Mo.
20	10 "	1	1	"	Crawford & McCrimmon, Brazil, Ind.
21	....	....	....	....	
22	8 feet.......	1	....	....	Fan run by screening engine.
23	6 x 16 "	1	....	....	" " "
24	10 "	1	1	Unknown,	Crawford & McCrimmon, Brazil, Ind.
25	10 "	1	1	"	" " " "
26	22 "	1	1	20	Springfield Car and Foundry Company.
27	....	....	....	....	
28	8 x 15 feet.......	1	1	Unknown,	Joplin Machine Works, Joplin, Mo.
29	....	....	....	....	
30	14 feet.......	1	1	20	Joplin Machine Works, Joplin, Mo.
31	12 "	1	....	....	
32	8 "	1	1	Unknown,	Oliveman & Hardwick, Erie, Pa.
33	3 x 10 "	1	1	"	Olds Engine Works, Indianapolis, Ind.
34	4 x 16 "	1	....	....	Threshing engine.
35	14 "	1	1	10	Manufacturers unknown; upright engine.
36	....	....	....	....	Furnace ventilation.
37	14 "	1	1	Unknown,	Unknown.
38	12 "	1	1	35	M. Leckie, Joplin, Mo.
39	12 "	1	....	....	Fan run by screening engine.
40	14 "	1	1	Unknown.	Crawford & McCrimmon, Brazil, Ind.

MINING LAWS.

GENERAL STATUTES OF 1897, CHAPTER 149,
COAL MINES AND MINING.

ARTICLE 1.—Preservation of Health and Safety in Mines.

ESCAPEMENT SHAFT—REGULATIONS.

Chapter 115, Laws of 1875.

§ 1. The owner or owners or lessee of each and every coal mine or colliery in this state which is worked by means of a shaft shall make and construct an escapement-shaft, making at least two distinct means of ingress and egress for all persons employed or permitted to work in such coal mine or colliery. Such escapement-shaft, or other communication with a contiguous mine, shall be constructed in connection with every stratum of coal worked in such coal mine or colliery; and every escapement-shaft or other communication with a contiguous mine as aforesaid shall be so constructed as to be accessible from every entry, plane or level in said coal mine or colliery, in case of a fire or other accident to the main shaft; provided, that the provisions of this law shall not apply to the coal mine at Leavenworth until the chambers, drifts or passages shall have reached the east side of the Missouri river.

§ 2. The time allowed for such construction shall be four months for the first fifty feet or fractional part thereof, and three months for every additional fifty feet in depth of said escapement-shaft so to be constructed; and every such escapement shall be separated from the main shaft by at least one hundred feet of natural strata.

[The two preceding sections should be considered in connection with the provisions of chapter 159 of the Laws of 1897, which act constitutes article 3 of this chapter.]

§ 3. Any owner or owners or lessee of any coal mine or colliery who shall neglect or refuse to comply with sections one

and two of this act shall be deemed guilty of a misdemeanor, and subject to a fine of not less than one hundred dollars nor more than one thousand dollars, or by imprisonment in the county jail not more than three months, or by both such fine and imprisonment.

§ 4. Any miner, workman or other person who shall knowingly obstruct or throw open any airways, or carry lighted lamps into places that are worked by the light of safety-lamps, or who shall move or disturb any part of the machinery of the hoisting engine or whim, or open a door in a mine and not have the same closed again, whereby danger is produced either to the mine or those at work therein, or who shall enter into any part of the mine against caution, or who shall disobey any order given in pursuance of this act, or who shall do any willful act whereby the lives and health of persons working in the mine, or the security of the mine or miners, or the machinery thereof is endangered, shall be deemed guilty of a misdemeanor, and upon conviction shall be punished by fine or imprisonment at the discretion of the court.

§ 5. The terms "owner" or "owners" or "lessee," as used in this act, shall include the immediate proprietor, lessee or occupier of any coal mine or colliery, or any person having on behalf of any owner or owners or lessee as aforesaid the care and management of any coal mine or colliery or any part thereof.

INSPECTOR OF MINES — QUALIFICATIONS — DUTIES.

Chapter 117, Laws of 1883, with Amendments.

§ 6. As soon as practicable after the passage of this act, the governor of the state with the advice and consent of the executive council shall appoint a qualified person to be inspector of mines provided for in this act. The qualifications for said office of inspector of mines shall be as follows, namely: He shall be a citizen of the United States, and shall have resided in the state of Kansas for two years, of temperate habits, of good repute, a man of personal integrity, shall have attained the age of thirty years, and shall have had at least five years experience working in and around coal mines; and he shall furnish evi-

dence of such practical as well as theoretical knowledge of the working of coal mines and noxious gases as will satisfy the governor and executive council of his capacity and fitness for the performance of the duties imposed upon an inspector of mines by the provisions of this act. His commission shall be for two years, to be computed from the thirtieth of June next.

§ 7. As often as vacancies occur by death, resignation or otherwise in said office of inspector of mines, the governor in the same manner shall fill the same by appointment for the unexpired term. Nothing in this act shall be construed to prevent the reappointment of any inspector of mines. The inspector of mines shall receive for his services an annual salary of two thousand dollars, to be paid in installments at the end of each quarter, by the state treasurer.

§ 8. He shall reside in the state, and keep an office as centrally located as practicable to the mining districts of the state. The executive council is hereby authorized to procure such instruments and chemical tests and stationery from time to time as may be necessary for the inspector in the proper discharge of his duties under this act, at the expense of the state, which shall be paid by the state treasurer, upon accounts duly certified by the executive council and audited by the auditor of the state. All the instruments, plans, book memoranda, notes, etc., pertaining to the office shall be the property of the state, and shall be delivered to his successor in office.

§ 9. The inspector of coal mines shall before entering upon the discharge of his duties give bond in the sum of three thousand dollars, with sureties to be approved by the executive council, conditioned for the faithful discharge of his duty, and take an oath or affirmation to discharge his duty impartially and with fidelity, to the best of his knowledge and ability.

§ 10. No person who shall act as a manager or agent of any coal mine, or as a mining engineer, or be interested in operating any coal mine, shall at the same time act as inspector of coal mines under this act.

OPENINGS IN MINES — SAFETY OF MINERS.

§ 11. It shall not be lawful after six months from the passage of this act for the owner, agent or operator of any coal mine to employ any person at work within said coal mine, or permit any person to be in said coal mine for the purpose of working therein, unless they are in communication with at least two openings, separated by natural strata of not less than eighty feet in breadth if the mine be worked by shaft or slope, and if worked by drift not less than fifty feet, provided however that such coal mine shall not exceed one hundred feet in depth from the surface to the coal; and for every additional one hundred feet or fractional part thereof six months additional time will be granted; but in all cases the number of men shall be limited not to exceed twenty-five until the second opening is perfected and made available; and a roadway to the same shall be kept open not less than three feet high and four feet wide, thereby forming a communication as contemplated in this act; but the limit herein prescribed as to the number working in the shaft before the completion of the second opening shall not apply to mines exceeding seven hundred feet in depth. And for failure to do as provided in this section, the owner, agent or operator shall be subject to the penalty provided for in section sixteen of this act [§ 21 of this chapter.] And in case of furnace ventilation being used before the second opening is reached, the furnace shall not be within forty feet of the foot of the shaft, and shall be secured from danger from fire by brick or stone walls of sufficient thickness; and the flues shall be composed of incombustible material to an extent of not less than thirty feet from the furnace and the mine while being driven for making or perfecting a second opening.

§ 12. In all cases where the human voice cannot be distinctly heard, the owner, agent or operator shall provide and maintain a metal tube from the top to the bottom of the shaft or slope, suitably adapted to the free passage of sound, through which conversation may be held between persons at the bottom and top of such shaft or slope; and there shall also be maintained

the ordinary means of signaling to and from the top and bottom of such shaft or slope.

§ 13. In all mines of 100 feet in depth or over from the surface of the ground an improved safety catch shall be used, and sufficient horns or flanges shall be attached to the sides of the drum of every machine that is used for lowering or hoisting persons into and out of said mine where steam is used, and adequate brakes shall be attached thereto. The main link attached to the swivel of the wire rope shall be made of the best quality of iron, and shall be tested by weights or other means satisfactory to the inspector of mines of the state; and bridle chains shall be attached to the main link from the cross pieces of the cage, and no single-link chain shall be used for lowering or raising persons into or out of said mine; and not more than six persons shall be lowered or hoisted by the machinery at any one time; and only sober, competent and experienced engineers shall be employed, and said engineer shall have attained at least the age of eighteen years; and on no account shall any coal be hoisted, or timber or any other material sent up or down, or empty cars, while persons are descending into or ascending out of said mine.

ESCAPEMENT-SHAFTS — EXAMINATION OF ENGINES AND BOILERS.

§ 14. In all coal mines hereafter opened or that shall hereafter go into operation in the state, the owner thereof, or owners, lessee, agent or operator, shall construct such escapement-shaft as is now required by law in this state, at the rate of fifty feet every six months until such escapement-shaft shall have been fully completed; and until such escapement-shaft is fully completed and connected with the main shaft it shall be unlawful to work over twenty-five men in said mine; provided, that the number of men to be employed in any mine seven hundred feet deep or more, prior to the time when a second or air shaft is sunk, shall be designated by the state mine inspector after a careful examination of all the conditions as to the safety and health of the men in the mines.

§ 15. Every steam boiler used in or around the coal mines of this state shall be provided with a proper steam gauge and water gauge, to show respectively the pressure of the steam and the hight of the water in the boiler, and to be also provided with a proper safety-valve; and the owner, agent or operator shall have the said boiler or boilers examined and inspected by a competent boiler-maker or other qualified person once in every six months, and the result of every examination shall be certified in writing and conveyed to the mine inspector, to be filed in the records of his office.

§ 16. In order to better secure the proper ventilation of every coal mine and promote the health and safety of the persons employed therein, the owner, agent or operator shall employ a competent and practical inside overseer, to be called "mining boss," who shall keep a careful watch over the ventilating apparatus, the air-ways, traveling-ways, pumps and pump timbers and drainage, and shall see that as the miners advance their excavations all loose coal, slate and rock overhead are carefully secured against falling in upon the traveling-ways. And every underground plane upon which persons travel, worked by self-acting pulleys, engines, windlasses or machinery of whatever description, shall be provided with proper means of signaling between the stopping-places and the ends of the plane; and shall furthermore be provided in every case, at intervals of not more than thirty feet, with sufficient man-holes for places of refuge. And every road on which persons traveling underground, where the coal is drawn by mules or other animals, shall be provided at intervals of not more than sixty feet with sufficient man-holes for places of refuge. And every mine shall be supplied with sufficient prop timber of suitable length and size for the places where it is to be used, and kept within easy access. And it shall also be the duty of the mining boss to measure the air current at least once per week at the inlet and outlet, and at the face of the workings, and keep a record of such measurements, and report the same to the inspector of the state once in every month. The safety-lamps used for examining the

mines, or which may be used for working therein, shall be furnished by and be the property of the owner of said mines, and shall be in charge of the agent of such mine. And in all mines generating explosive gases the doors used in assisting or directing the ventilation of the mine shall be so hung and adjusted that they will close themseves, or be supplied with springs or pulleys so that they cannot be left standing open; and boreholes shall be kept not less than twelve feet in advance of the face of every working place, and when necessary on the sides, if the same is driven toward and in dangerous proximity to an abandoned mine suspected of containing inflammable gases or which is inundated with water.

MAP OR PLAN OF COAL MINE.

§ 17. The owner, agent or operator of every coal mine shall make or cause to be made within six months after the passage of this act an accurate map or plan of the workings of such coal mine, and each and every vein thereof, on a scale not exceeding one hundred feet to the inch, and showing the bearings and distances, which shall be kept in the office of such coal mine; and it shall be the duty of the owner, agent or operator of such coal mine to furnish the state inspector with a true copy of said map or plan, the same to be deposited at his office. And such owner, agent or operator shall cause, on or before the tenth day of July of each year, a plan of the progress of the workings of such coal mine during the year past to be marked on the original map or plan of the said coal mine, and the inspector shall correct his map or plan of said workings in accordance with the above plan or map thus furnished. And when any coal mine is worked out or abandoned the fact shall be reported to the inspector, and the plan or map of such coal mine in his office shall be carefully corrected and verified; provided, if the owner, agent or operator of any coal mine shall neglect or refuse or for any cause fail for the period of two months after the time prescribed to furnish the said map or plan as hereby required, or if the inspector shall find or have reason to believe that any map or plan of any coal mine

furnished in pursuance of this act is materially inaccurate or imperfect, he is hereby authorized to cause a correct map or plan of the actual workings of said coal mine to be made at the expense of the owner, agent or operator thereof, the cost of which shall be recovered from said owner, agent or operator as other debts are recoverable by law; provided, that if the map or plan which the inspector claimed to be incorrect shall prove to have been correct, then the said expense shall be paid by the inspector.

DUTIES OF INSPECTOR OF MINES.

§ 18. The inspector of mines shall devote the whole of his time to the duties of his office. It shall be his duty to examine each mine in the state as often as possible, and at least twice each year, to see that all provisions of this act are observed and strictly carried out; and he shall make a record of all examinations of mines, showing the condition in which he finds them, the number of persons employed in and about each mine, the extent to which the law is obeyed, the progress made in the improvements sought to be secured by the passage of this act, the number of accidents and deaths resulting from injuries received in the mines, and all other facts of public interest concerning the condition and progress of mining in this state. In order to facilitate the inspector in his duties, it shall be the duty of all coal operators to make quarterly statements to the inspector of the amount of coal mined, and the number of miners and other persons employed around the mines each quarter. The inspector's record and all matters concerning the coal-mining business of public interest shall be embodied in the inspector's annual report made to the governor on the first day of February each year.

§ 19. That the inspector may be enabled to perform the duties here imposed on him, he shall have the right at all times to enter any coal mine to make examination or obtain information. He shall notify the owners, lessees or agents immediately of the discovery of any violations of this act, and of the penalty imposed thereby for such violation; and in case of such notice

being disregarded for the space of ten days he shall institute a prosecution against the owner, owners, lessee or agent of the mine, under the provisions of section sixteen of this act [§ 21 of this chapter.] In any case, however, where in the judgment of the inspector delay may jeopardize life or limb, he shall at once proceed to the mine where the danger exists and examine into the matter, and if after full investigation thereof he shall be of the opinion that there is immediate danger he shall apply in the name of the state to the district court of the county in which the mine may be located, or to the district judge in vacation, for an injunction to suspend all work in and about such mine; whereupon said court or judge in vacation, if the cause appears to be sufficient, after hearing the parties and their evidence as in like cases, shall issue a writ to restrain the working until all cause of danger is removed. And the costs of said proceedings, including the charges of attorney prosecuting said application, shall be borne by the owner of the coal mine; provided, that no fee exceeding the sum of twenty-five dollars shall be taxed in any one case for the attorney prosecuting such case; provided further, that if said court (or judge in vacation) shall find the cause not sufficient, then the case shall be dismissed, and the costs shall be borne by the state or county, in the discretion of the court or judge.

PROMPT NOTICE OF INJURY OR DEATH TO BE GIVEN.

§ 20. Whenever by reason of any explosion or other accident in any coal mine, or the machinery connected therewith, loss of life or serious personal injury shall occur, it shall be the duty of the person having charge of such coal mine to give notice thereof forthwith to the inspector, and if any person is killed thereby, to the coroner of the county, who shall give due notice of the inquest to be held. It shall be the duty of the inspector upon being notified as herein provided to immediately repair to the scene of the accident, and make such suggestions as may appear necessary to secure the future safety of the men; and if the results of the explosion do not require an investigation by the coroner he shall proceed to investigate and ascer-

tain the cause of the explosion or accident, and make a record thereof, which he shall file as provided for; and to enable him to make the investigation he shall have power to compel the attendance of persons to testify, and to administer oaths or affirmations. The cost of such investigation shall be paid by the county in which the accident occurred, in the same manner as costs of inquests held by the coroner or justices of the peace are paid.

§ 21. Any owner or owners, lessee, agent or operator of any coal mine who shall neglect or refuse to comply with sections one, two, three, four, five, six and eight of this act [§§ 11. 12, 13, 15, 16 and 17 of this chapter,] shall be deemed guilty of a misdemeanor, and subject to a fine of not less than one hundred dollars nor more than one thousand dollars, or by imprisonment in the county jail not more than three months, or by both such fine and imprisonment. All penalties recovered under this act shall be applied, in the county in which the fine is collected, to the support of common schools.

§ 22. No person under twelve years of age shall be allowed to work in any coal mine, nor any minor between the ages of twelve and sixteen years, unless he can read and write, and furnish a certificate from a school teacher, which shall be kept on file, showing that he has attended school at least three months during the year; and in all cases of minors applying for work, the agent of such coal mine shall see that the provisions of this section are not violated; and upon conviction of a willful violation of this section of this act, the agent of such coal mine shall be fined in any sum not to exceed fifty dollars for each and every offense.

§ 23. The terms "owner," "owners," "lessee," "agent," or "operator," as used in this act, shall include the immediate proprietor, lessee or occupier of any coal mine, or any person having on behalf of any owner or owners or lessee as aforesaid the care and management of any coal mine, or any part thereof.

OWNER AND OPERATOR OF MINES — LIABLE FOR INJURIES.

§ 24. For any injury to person or property occasioned by any violation of this act, or any willful failure to comply with its provisions by any owner, lessee or operator of any coal mine or opening, a right of action against the party at fault shall accrue to the party injured for the direct damage sustained thereby; and in any case of loss of life by reason of such violation or willful failure, a right of action against the party at fault shall accrue to the widow and lineal heirs of the person whose life shall be lost, for like recovery of damages for the injury they shall have sustained.

No duty devolving upon the owner or operator of a coal mine, or other work of a dangerous character, can be delegated to an agent or employee so as to relieve the owner or proprietor from his personal responsibility; Coal Co. v. Britton, 3 Ct. App. 293.

While it is the duty of the owner or operator of a coal mine to provide his employees with a reasonably safe place to perform their labor, he is only bound to exercise ordinary care in providing for the safety of the men engaged in the mine so far as it could reasonably be expected; Coal Co. v. Britton, 3 Ct. App. 293.

POWDER IN MINE — QUANTITY PROHIBITED.

§ 25. It shall be unlawful for any miner or other person to take into or have in his possession in any coal-mine shaft, slope or pit in this state, more than twelve and one-half pounds of powder or any other explosive substance at any one time; and all such powder or other explosive substance shall be kept in a tight box securely locked, and such boxes shall be kept at least twelve yards from the working face in all such coal-mine slopes, drifts or pits; and it shall be the duty of all pit-bosses or other persons who shall be in charge of any coal-mine slope, drift or pit in this state to keep watch over and see that the provisions of this act are complied with; and any person violating or neglecting to comply with the provisions of this act shall be deemed guilty of a misdemeanor, and shall on conviction before any court having jurisdiction thereof be fined in any sum not less than ten nor more than fifty dollars, or by imprisonment in the county jail not more than thirty days, for each and every such offense; and the possession of more than twelve and

one-half pounds of powder or any other explosive substance in such coal-mine slope or drift shall be *prima facie* evidence of the person taking said powder or other explosive substance into such mine, slope or drift.

§ 26. Any miner, workman, or other person who shall intentionally injure any safety-lamp, instrument, airway, brattice, or obstruct or throw open airways, or carry lighted lamps, pipes or matches into places worked by the light of safety-lamps, or shall move or disturb any part of the machinery, or who shall open a door and not close it again, or enter any place of the mine against caution, or disobey any order given in carrying out the provisions of this act, or who shall do any willful act whereby the lives or health of persons or the security of the mine or the machinery is endangered, shall be guilty of a misdemeanor, and upon conviction shall be punished by fine or imprisonment, at the direction of the court.

FENCES AND PASSAGEWAYS, TO SECURE SAFETY.

§ 27. All machinery about mines and the entrance of every abandoned shaft or slope shall be properly fenced off, and the top of each shaft and each landing of the same shall be fenced around with a fence not less than three feet high on every side, except the side or sides used for loading and unloading the cages, and this side or sides shall have gates or bars which shall be kept closed at all times except during the active use of the cages at these places; and there shall be cut in the side of every hoisting shaft at the bottom thereof a traveling way sufficiently high and wide to enable persons to pass the shaft in going from one side of the mine to the other without passing over or under the cages or other hoisting apparatus.

SHOTS TO BE FIRED DAILY.

Chapter 172, Laws of 1889.

§ 28. All owners, lessees, operators of or any other person having the control or management of any coal shaft, slope, drift or pit in this state employing miners to work therein, shall employ shot-firers to fire the shots therein. Said shots shall be fired once a day on each day when any such shaft, slope, drift

or pit is in operation, but shall not be fired until after all miners and other employees working therein shall have been hoisted out of said mine.

§ 29. It shall be unlawful for any miner or any person other than the shot-firers provided for in section one of this act [the next preceding section] to fire any shot in any coal shaft, slope, drift or pit in this state. Any miner or other person engaged in mining coal in this state who shall drill any hole or fire any shot in the coal vein at the working face of any room or entry until so much of said coal vein at said working face as the said shot or shots are intended to throw down shall have been undermined to the depth of not less than two feet, or sheared or cut to the full depth of the drill or shot hole and of the full thickness of the coal vein in rooms, or shall have been sheared to the full depth of the drill or shot hole and the full thickness of vein in entries, or who shall so direct the drilling of such holes as to include between such shearing or mining and the back or rear end of the hole a greater width of coal than is contained between such shearing or mining and the mouth of the hole, shall be deemed guilty of a misdemeanor, and fined as hereinafter provided.

§ 30. Any owner, lessee, operator or other person having the control or management of any coal shaft, slope, drift or pit who shall refuse to furnish the shot-firers as provided for in section one of this act [§ 28 of this chapter,] shall be deemed guilty of a misdemeanor, and on conviction thereof shall be fined in any sum not less than fifty nor more than two hundred dollars for each offense, or imprisonment in the county jail in the county where such offense is committed for a period not to exceed thirty days, or by both such fine and imprisonment; proceedings to be instituted in any court having competent jurisdiction.

§ 31. Any miner or other person who shall fire any shot in violation of section two of this act [§29 of this chapter] shall be deemed guilty of a misdemeanor, and on conviction thereof shall be fined in any sum not less than fifty dollars nor more than two hundred dollars, or imprisonment in the county jail

in the county where such offense is committed not to exceed thirty days, or by both such fine and imprisonment; proceedings to be instituted in any court having competent jurisdiction.

ARTICLE 2.—Duties and Liabilities of Operators of Mines.
Chapter 159, Laws of 1897.

§ 32. It shall be unlawful for any mine owner, agent, lessee or operator of any coal mine, or any other underground workings where any kind of material is mined or excavated, in either shaft mine, slope mine, or drift mine, by system of room and pillar, to mine or cause to be mined by any employee therein, in any of said mines, any minerals mined by bushel, ton or other rates, to excavate coal or other minerals in an advance space of forty feet, unless break-throughs are made ranging in distance as follows: Forty feet shall constitute the distance between break-throughs, which shall be made through the pillar which divides either rooms, air courses or entries, where any of said rooms, air courses or entries are in operation, and in no case shall the distance exceed the aforesaid distance, namely, forty feet, irrespective of thickness or distance of the pillar or pillars which divide such rooms, air courses or entries.

§ 33. Said break-throughs shall be at least six feet wide and the full hight of coal strata or other minerals mined which do not exceed six feet in hight, and in no case shall the air courses have less than twenty-one feet of an area where mines are operated on room-and-pillar system; and the compensation for making such break-throughs shall be regulated by or between the employer and employee; and any room, air course or entry or any other working places where miners or others are employed shall cease operations at the working faces until said break-throughs are perfected, as herein specified in section one of this act, [the next preceding section.] And said break-throughs shall be filled with either slate rock, or closed by brattice, to make the same air-tight, as soon as the second or succeeding break-throughs are made. And in case any of such break-throughs are partly opened or torn down by the concussion of shots or blasts, or by premature explosion or otherwise, the foreman or

superintendent or agent in each or any of the said mines shall immediately cause any of such break-throughs to be properly closed and made air-tight as soon as notified by any employee.

§ 34. Every mine owner, agent, lessee or operator of coal mines or underground workings of the character mentioned in section one of this act [§ 32 of this chapter,] shall provide and hereafter maintain for every mine ample means of ventilation, affording not less than one hundred cubic feet of air in every such mine per man per minute. Said volume of air shall be directed or circulated where any person or persons may be working in any of said mines.

§ 35. The inspector of mines shall cause the volume of air to be increased when necessary to such an extent as will dilute, carry off and render harmless the noxious gases generated therein. And mines generating fire-damp shall be kept free of standing gas, and every working place shall be carefully examined every morning with a safety-lamp by an examiner or fire-boss before miners or other employees enter their respective working places. Said examiner or fire-boss shall register the day of the month at the place of the workings, and also on top in a book which shall be kept in the weighmaster's office for such special purpose, and as proof of inspection he shall daily record all places examined in said book, and in case of danger where fire-damp may have accumulated during the absence of any person or persons employed therein, said examiner or fire-boss must notify the miners or those employed therein, or those who may have occasion to enter such places. And the hydrogen or fire-damp generated therein must be diluted and rendered harmless before any person or persons enter such working or abandoned part of the mine with a naked light.

§ 36. It shall be the duty of the owner, lessee or operator of any mine where the natural strata are not safe in or around all workings, pumping and escaping shafts, to securely case line or otherwise make said places secure, and all escapement-shafts shall be provided with stairways securely fastened, so as to bear

the combined weight of not less than fifteen men ascending or descending the same. Said stairways shall be so constructed as not to exceed forty-five degrees of elevation by each section of said stair, and each section shall have substantial guard-rails securely fastened, and the stairways shall be separately partitioned from the parts of such shafts used as upcasts or downcasts, and the traveling ways between the bottom of the main shaft and the escaping shaft shall be at least five feet in hight. Said traveling ways shall be kept clear of all obstructions, and standing or stagnant water shall not be allowed to accumulate in any traveling way between the upcast and the downcast shafts. And in case of mine shafts which are over one hundred and fifty feet in depth, where stairways cannot be conveniently constructed, other safe means of hoisting the persons employed in any such mine must be kept ready at all times, so as to be available in case of accident to the regular hoisting shaft or machinery in use at the same.

§ 37. It shall be the duty of the foreman, cager, or whosoever may have charge at the bottom of any shaft, to give the proper signal to the top man and engineer whenever any six employees who work therein are ready to ascend, by day or night, and for the making such ascent it shall be the duty of the bottom cager to give them an empty cage by which they can ascend. And every road on which persons travel underground when the coal is drawn by mules or other power shall be provided at intervals of not more than thirty feet with sufficient man-holes for places of refuge.

§ 38. It shall be the duty of the owner, lessee or operator of every mine to provide and maintain airways of sufficient dimensions, and in no case shall the area of the air course be less than twenty-one feet in mines operated on room-and-pillar system.

§ 39. Standing or stagnant water shall not be allowed to remain in air courses, entries, traveling ways or rooms. Obstructions of any kind must not be placed in cross-cuts, rooms, or entries used as airways. And in case of a fall of roof, or

where the sides of such airways cave in, it shall be the duty of the mine boss or agent in any such mines to cause such falls or obstruction to be removed immediately and the roof and sides made secure.

§ 40. All main airways in any of the underground workings shall be examined at least twice a week by the mine boss or agent, or some other competent person so directed by said mine boss or agent, and a report of such inspection shall be forwarded to the office of the state inspector of mines at least once a month.

§ 41. It shall be the duty of the mine boss or agent in charge of any mine where coal dust or any other inflammable ingredients may accumulate to cause the same to be properly sprinkled or saturated once a day, and oftener if necessary, in either air courses, entries, rooms or cross-cuts.

§ 42. No employee or other person in mines is allowed to leave trap-doors or air-gates open any longer than while passing through said gates or doors. And any person who accidentally or otherwise tears down any brattice cloth must immediately notify the mine boss or the individual having supervision of the air in such mine, and the same must be replaced as soon as notice thereof is given to the mine boss or person in charge of the air.

§ 43. In order to facilitate the inspector of mines in his duties, it shall be the duty of all coal operators and coal companies or lessees or other persons engaged in mining or producing coal to make a quarterly statement to the mine inspector of the amount of all coal mined, the number of miners employed, number of day men, number of boys, and all other persons employed in or around said mine or mines, not later than ten days after the end of each quarter, and they shall also state the price paid miner per ton or bushel, the price paid to day hands per day, the number of days worked by miners and by day men, the number of accidents, and deaths resulting from injuries in and around the said mine or mines. It shall also be the duty of the mine inspector to furnish all coal operators and all coal companies

or lessees or other persons engaged in mining or producing coal with printed blank forms every quarter, for the purpose of making out said report as this act herein provides for.

§ 44. No person employed in any mine shall use any kind of oil other than lard oil for lighting purposes, except when repairing downcast or upcast shafts.

§ 45. The inspector of mines is duly authorized to enforce the provisions of this and all other acts relating to mines or mining; and he is hereby empowered to institute proceedings in the name of the state of Kansas against any miner, owner, agent, lessee or operator of any mine, or any employee employed therein, who refuses to comply with the provisions of this act, after ten days' notice. The inspector is hereby empowered in all cases where mines are not worked or operated in strict accordance with this act to order the employees employed in such mine to suspend operations, and if in his judgment there is immediate danger, he can order such mine to suspend operation until the matter of which he complains in relation to this act is complied with.

§ 46. The inspector is hereby authorized to furnish every mine owner, agent, lessee or operator of every mine which he knows to be in operation with a printed copy of this act, which shall be kept conspicuously posted at or near the top of any of said mines, and it shall be the duty of the mine boss or agent in charge to call the attention of the miners or others employed to the provisions of this act.

§ 47. In case of non-compliance with sections one, two, three, four, five, six, seven, eight, nine, ten, eleven, twelve, thirteen, fourteen and fifteen of this act [§§ 32 to 46 of this chapter,] by any owner, operator, agent or lessee of any mine, or any miner or other employee working therein, upon whom any duty is cast by any of said sections, he shall be deemed guilty of a misdemeanor, and shall upon conviction of the same, for each offense, be punished by a fine of not less than one hundred dollars and not to exceed three hundred dollars, and by imprisonment in the county jail for a period of not less than thirty

days and not to exceed ninety days, or by both such fine and imprisonment, in any court having competent jurisdiction; provided, that this act shall be construed as to affect or apply only to coal mines of this state, or any person or persons operating or owning such coal mines.

ARTICLE 3.—Weighing Coal at the Mine.
Chapter 188, Laws of 1893.

§ 48. It shall be unlawful for any mine owner, lessee or operator of coal mines in this state, employing miners at bushel or ton rates or other quantity, to pass the output of coal mined by said miners over any screen or other device which shall take any part from the value thereof before the same shall have been weighed and duly credited to the employees and accounted for at the legal rate of weights as fixed by the laws of Kansas.

§ 49. The weighman employed at any mine shall subscribe an oath or affirmation before a justice of the peace or other officer authorized to administer oaths to do justice between employer and employee, and to weigh the output of coal from mines in accordance with the provisions of section one of this act [the next preceding section.] Said oath or affirmation shall be kept conspicuously posted in the weigh office, and any weigher of coal or person so employed who shall knowingly violate any of the provisions of this act shall be deemed guilty of a misdemeanor, and upon conviction shall be punished by a fine of not less than twenty-five nor more than one hundred dollars for each offense, or by imprisonment in the county jail for a period not to exceed thirty days, or by both such fine and imprisonment.

§ 50. The miners employed by or engaged in working for any mine owner, operator or lessee in this state shall have the privilege, if they so desire, of employing at their own expense a check-weighman, who shall have like rights and privileges in the weighing of coal as the regular weighman, and be subject to the same oath and penalties as the regular weighman.

§ 51. Any person or persons having or using any scale or scales for the purpose of weighing the output of coal at mines

so arranged or constructed that fraudulent weighing may be done thereby, or who shall knowingly resort to or employ any means whatever by reason of which such coal is not correctly weighed and reported in accordance with the provisions of this act, shall be deemed guilty of a misdemeanor, and shall upon conviction for each offense be punished by a fine of not less than two hundred dollars nor more than five hundred dollars, or by imprisonment in the county jail for a period not to exceed sixty days, or by both such fine and imprisonment.

§ 52. Any provision, contract or agreement between mine owners or operators thereof and the miners employed therein whereby the provisions of section one of this act [§ 48 of this chapter] are waived, modified or annulled shall be void and of no effect; and the coal sent to the surface shall be accepted or rejected, and if accepted shall be weighed in accordance with the provisions of this act; and a right of action shall not be invalidated by reason of any contract or agreement.

§ 53. The provisions of this act shall also apply to the class of workers in mines known as loaders, engaged in mines wherein mining is done by machinery. Whenever the workmen are under contract to load coal by the bushel, ton, or any quantity the settlement of which is had by weight, the output shall be weighed in accordance with the provisions of this act.

ARTICLE 4.—Mining under Cities—Contract by Ordinance.
Chapter 28, Laws of 1869.

§ 54. Any city of the first or second class in which an organized coal company shall exist may by ordinance contract with such company for the exclusive and perpetual right to mine beneath the streets, alleys and public grounds thereof, upon the agreement to pay one-fourth a cent per bushel upon each and every bushel raised by said company, one-half of which amount shall be paid into the general fund of said city, and the other half shall be paid to the treasurer of the state in aid of the school fund.

§ 55. Any coal company which shall have heretofore obtained

by ordinance from any city of the first class a contract for the exclusive right to mine under the streets, alleys and public grounds thereof shall be entitled to the priority, exclusion and perpetuity of such ordinance, which is hereby validated and confirmed; provided, that within thirty days after the passage of this act such company shall file with the secretary of state their consent thereto and stipulate to pay the amount specified in the first section hereof, and to comply with the conditions named in the ordinance.

§ 56. Nothing in this act shall be construed to relieve such company from making compensation to the owners of private property for any injury done in mining operations.

ARTICLE 5.—Enjoining Trespasses and Trespassers.

Chapter 127, Laws of 1877.

§ 57. Whenever an affidavit properly verified by the person aggrieved, or his agent or attorney, shall be presented to the district court of the proper county during term time, or to the judge thereof in vacation, in which it shall be made to appear that such person shall have good reason to believe that any other person or persons, corporation or corporations, are without authority encroaching upon the land of the person aggrieved, whether the same be held by lease or otherwise, and are mining or taking coal therefrom, it shall be the duty of the said court or judge to order and direct the county surveyor to survey the mine or mines of the person or persons, corporation or corporations accused thereof, for the purpose of ascertaining the truth thereof; the party applying for such survey to first give bond in such sum as may be deemed sufficient by said court or judge, and the same to be at the time approved by said court or judge, conditioned for the payment of the costs of said survey.

§ 58. Upon the making of such order and approval of said bond, it shall be the duty of the county surveyor to forthwith make such survey, and to file his written report thereof with the clerk of such district court.

§ 59. When it shall be made to appear by petition verified by

the oath of the plaintiff, his agent or attorney, and by the survey of the county surveyor, that any person or persons, corporation or corporations, is or are without authority mining or taking coal from the land of the plaintiff, whether held by lease or otherwise, it shall be the duty of the proper district court in term time, or the judge thereof in vacation, to grant a temporary injunction restraining such person or persons, corporation or corporations, from mining or taking coal from such land until the further order of the court or judge.

§ 60. The proceedings in such cases shall be in all respects similar to the course of procedure in actions for injunction.

§ 61. It shall be the duty of every person or corporation owning coal mines, and every person in charge of the same, to provide the county surveyor with all the ordinary means of ingress and egress, to make any survey thereof he may be ordered to make; and any person or persons in any way interfering, molesting or hindering such county surveyor in making any survey he may be ordered to make under the provisions of this act shall be guilty of a misdemeanor, and shall be liable on each offense to a fine of not less than ten dollars and not more than one hundred dollars, to be prosecuted and recovered as in other cases of misdemeanor.

SURVEY OF MINES — PREVENTION OF TRESPASSES.

Chapter 115, Laws of 1881.

§ 62. When any owner, tenant or subtenant of a lot or lots or tract of land shall file with any justice of the peace within the county in which said lot or lots or tract of land may be situated his or her affidavit, or the affidavit of any other credible person for them, stating that from knowledge, information or belief the party or parties owning, controlling or working the adjoining lot or lots or tract of land, and upon which said party or parties are sinking shafts, mining, excavating and running drifts, and that said drifts in which said parties are digging, mining and excavating any mineral ore or veins of coal extend beyond the lines and boundaries of said lot or lots or tract of land owned, controlled or worked by them, and

have entered into and upon the premises of the party or parties making said affidavit or for whom said affidavit is made, the justice of the peace, after first being tendered his lawful fees, shall issue his written order, and deliver or cause the same to be delivered to the county surveyor or his deputy, commanding him after his reasonable fees have been tendered, to proceed without delay to survey said drift, by entering any and all shafts upon said lot or lots or tract of land that he (the surveyor) may see fit, for the purpose of ascertaining the course and distance of said drift or drifts, and to locate the same upon the surface.

§ 63. The surveyor shall before entering upon said duties read said order to the party or parties owning, controlling or working any shaft or shafts on said lot or lots or tract of land.

§ 64. If any person shall refuse, hinder or prevent said county surveyor or his deputy and his assistants from entering said shaft or shafts or drifts to make the survey so ordered by the justice of the peace, said person or persons so offending shall on conviction be adjudged guilty of a misdemeanor, and punished by imprisonment in the county jail for a term of not exceeding one year, or by fine not exceeding three hundred dollars, or by both such fine and imprisonment.

GENERAL INDEX.

A.

B.

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E.

M.

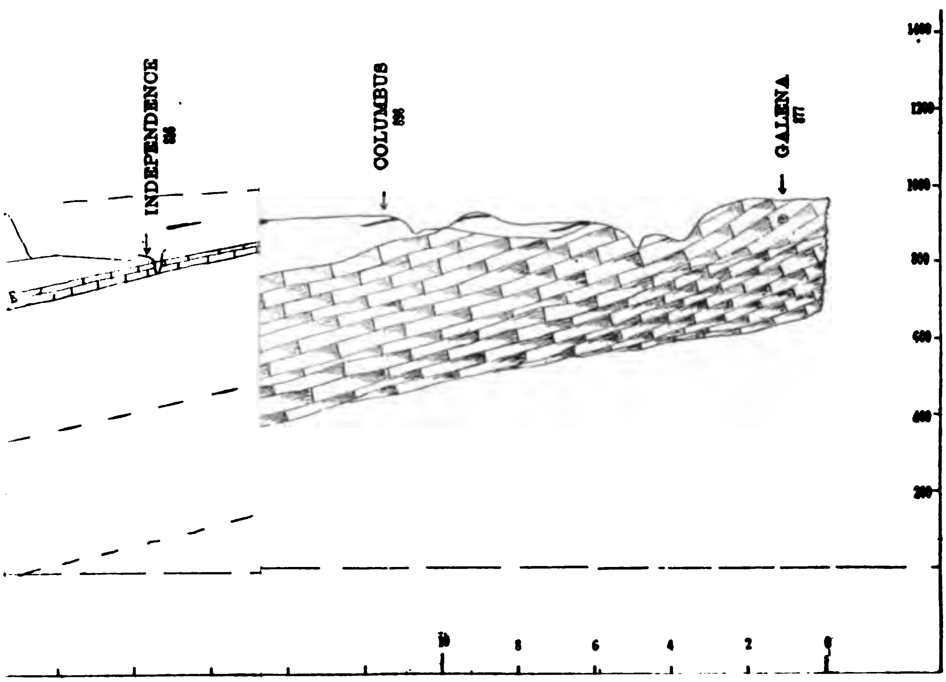
Q.

R.

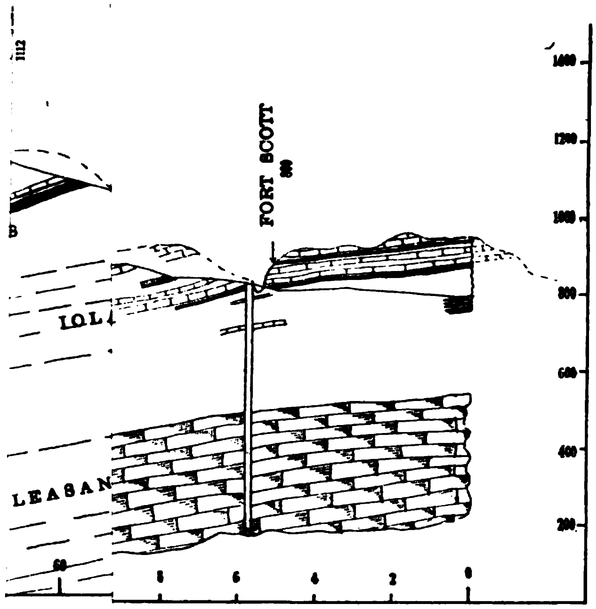
S.

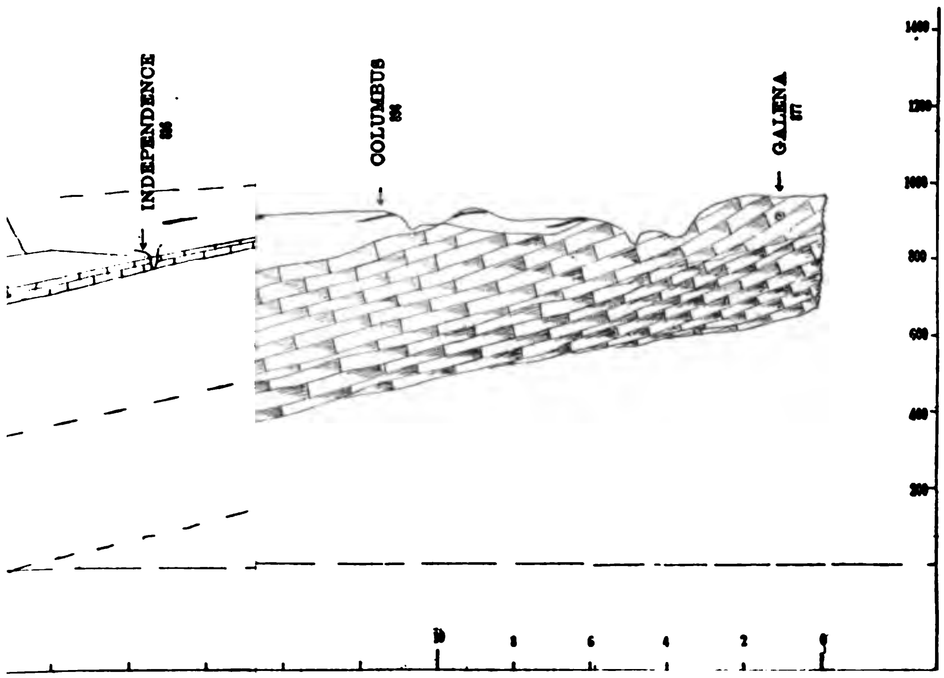
T.

Volume III, Plate I.



Volume III, Plate II.

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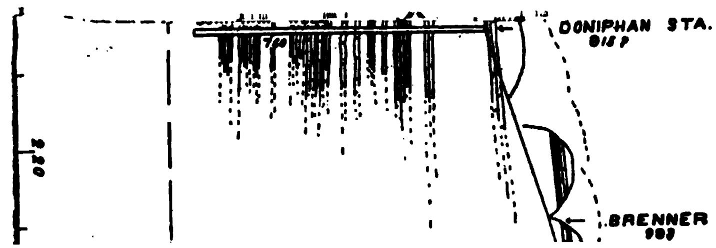
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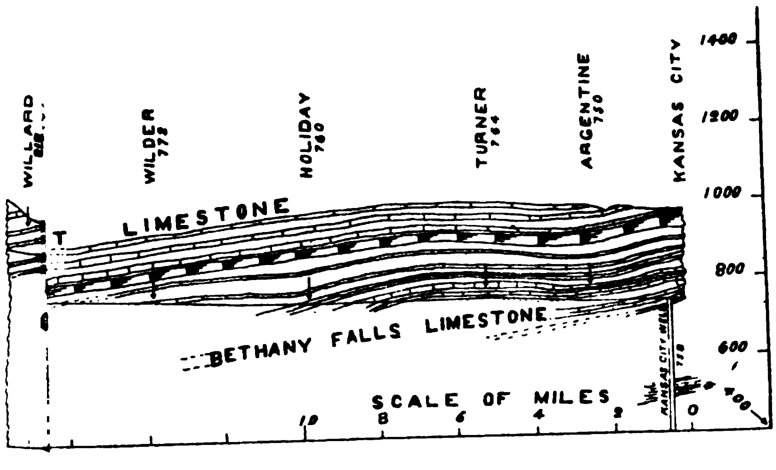
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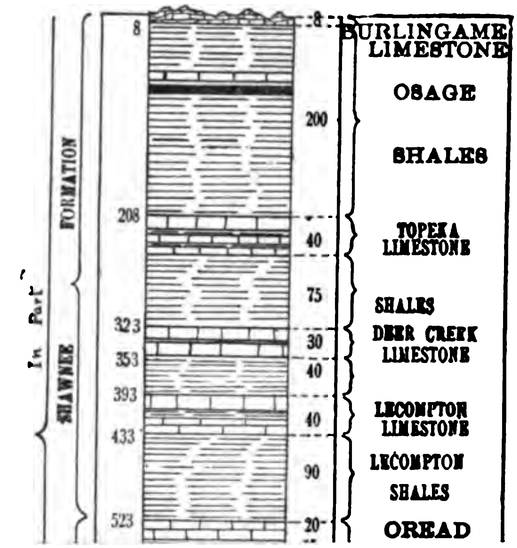
GENERALIZED SECTION OF COAL MEASURES



Record of a Deep Well at Oswego, Labette County.

PLATE XXI.

Bored for Oil and Gas. **Reported by H. C. Draper.**

	MATERIAL.	Thickness of Strata.	Depth to Bottom of Strata.
1	Soil and Clay	6 feet	6 feet.
2	Bastard Limestone	6 "	12 "
3	Black Slate Shale	4 "	16 "
4	Bluish Sandstone	3 "	19 "
5	Soapstone Shale	4 "	23 "
6	Soft Sandstone	6 "	29 "
7	Dark blue Shale	536 "	565 "
8	Gas Vein		
9	Geode Rock, conglomerate	20 feet	585 "
10	Bluish gray Lime and Sand Rock, full of grease, very dark and sticky	40 "	625 "
11	Limestone and Flint	75 "	700 "

Record of Mound Valley Artesian Well, Labette County.

PLATE XXI.

Drilled with Churn Drill. **Reported by L. P. Crossman.**

	MATERIAL.	Thickness of Strata.	Depth to Bottom of Strata.
1	Soil	1 feet 8 inches	1 feet 8 inches.
2	Limestone	12 "	13 " 8 "
3	Slate Shale	4 "	17 " 8 "
4	Soapstone Shale—Water	4 "	21 " 8 "
5	Limestone	13 "	34 " 8 "
6	Soapstone Shale	12 "	46 " 8 "
7	Limestone	16 "	62 " 8 "
8	Soapstone Shale	3 "	65 " 8 "
9	Sandstone	1 "	66 " 8 "
10	Soapstone Shale	4 "	70 " 8 "
11	Sandstone	1 "	71 " 8 "
12	Strong Water, very soft	2 "	73 " 8 "
13	Soapstone Shale	100 "	173 " 8 "
14	Limestone	4 inches	174 "
15	Soapstone Shale	8 "	174 " 8 "
16	Limestone	26 feet	200 " 8 "
17	Slate Shale—Gas	2 "	202 " 8 "
18	Slate Shale	15 "	217 " 8 "
19	Limestone	15 "	232 " 8 "
20	Soapstone Shale—Salt water	44 "	276 " 8 "
21	Limestone, dark gray, with strong odor	20 "	296 " 8 "
22	Slate Shale	5 "	301 " 8 "
23	Limestone	19 "	320 " 8 "
24	Slate Shale, very black	5 "	325 " 8 "
25	Limestone in layers, mixed with Soapstone Shale	10 "	335 " 8 "
26	Black Slate Shale	10 "	345 " 8 "
27	Soapstone Shale, mixed with stratas of Slate and Sand Shale, and also some Mundic or Sulphur	36 feet	381 feet 8 inches.
28	Sandstone	7 "	388 " 8 "
29	Soapstone Shale and thin layers of Sandstone	8 "	396 " 8 "
30	Conglomerate Rock, exceedingly hard, took five hours to drill through	1 "	397 " 8 "
31	Dark Slate Shale and some Soapstone Shale,	42 "	439 " 8 "
32	Black Shale	2 "	441 " 8 "
33	Sandstone—Strong Gas. Coal 4 to 8 inches at 449	5 "	446 " 8 "
34	Slate Shale, layers of Soapstone Shale, thin layers of Sandstone, some Mundic	51 "	497 " 8 "
35	Soapstone Shale	7 "	504 " 8 "
36	Slate Shale	7 "	511 " 8 "
37	Soapstone Shale	8 "	519 " 8 "
38	COAL	1 "	520 " 8 "
39	Slate Shale, very black and brittle	12 "	532 " 8 "
40	Slate Shale, not so black, thin layers of Sandstone and Mundic	10 "	542 " 8 "
41	Sandstone	7 "	549 " 8 "
42	Soapstone Shale, very soft and sticky, a species of Fire Clay (?), reddish in parts,	70 "	619 " 8 "
43	Slate Shale, very black and hard	2 " 6 inches	622 " 2 "
44	Sandstone, white, gradually growing harder until of Grindstone Grit at the bottom,	15 feet	637 feet 2 inches.
45	Soapstone Shale, white, soft, and sticky	34 "	671 " 2 "
46	Sandstone, white, Grindstone Grit	4 "	675 " 2 "
47	Light Soapstone Shale	7 "	682 " 2 "
48	Black Slate Shale	7 "	689 " 2 "
49	White Soapstone Shale	7 "	696 " 2 "
50	Black Slate Shale, some Sand in nugget form, some fossil particles of Limestone	7 "	703 " 2 "
51	Soapstone Shale, soft, white, with nuggets of Limestone and Sand	15 "	718 " 2 "
52	Soapstone Shale, very soft and sticky, hard to mix in water	5 "	723 " 2 "
53	Black Slate Shale	7 "	730 " 2 "
54	White Soapstone Shale	5 "	735 " 2 "
55	Black Slate Shale	27 " 6 inches	762 " 8 "

Figure 1.

OSWEGO WELL

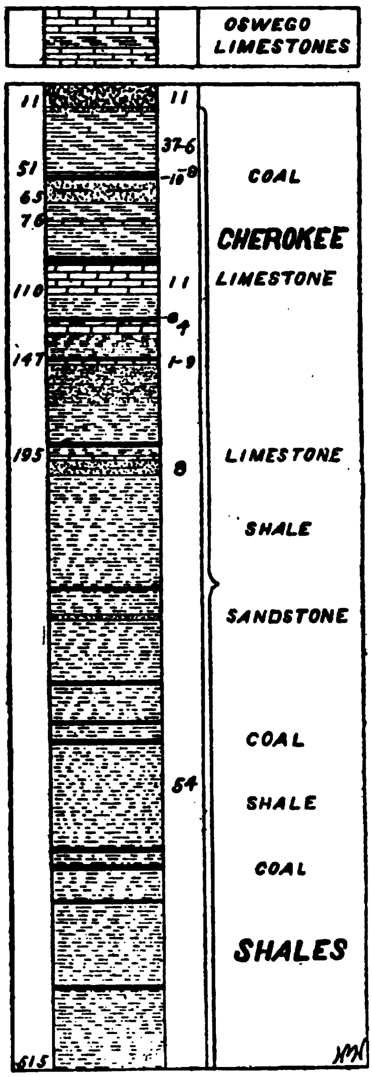
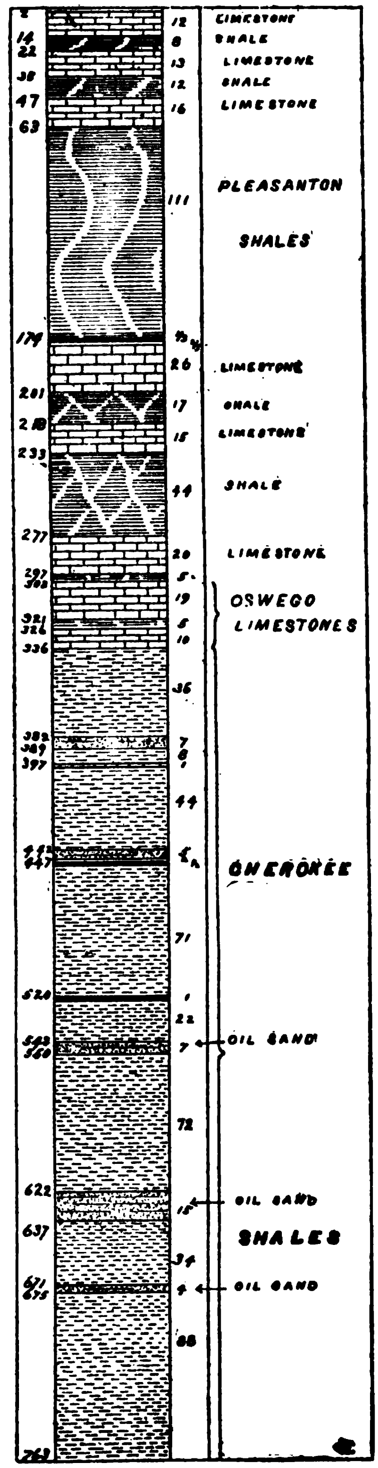


Figure 2.

MOUND VALLEY WELL



Record of Cherryvale City Well, Montgomery County.

PLATE XXII.

Obtained from the City Clerk's Records.

	MATERIAL.	Thickness of Strata.	Depth to Bottom of Strata.
1	Soil and Clay	6 feet 6 inches	6 feet 6 inches.
2	Limestone, calcareous, carrying crinoids	6 " 6 "	13 "
3	Sandstone	14 "	27 "
4	Shale, sandy	5 "	32 "
5	Sandstone	11 "	43 "
6	COAL	3 inches	43 " 3 inches.
7	Shale, gray	6 feet 9 "	50 "
8	Sandstone	34 "	84 "
9	Shale, blue	6 "	90 "
10	Limestone	13 "	103 "
11	Blue Shale	50 "	153 "
[illegible]	Limestone	10 "	163 "
[illegible]	[illegible]	55 " 10 inches	218 " [illegible] inches.

Figure 1.

CHERRYVALE WELL
Diamond Drill Core

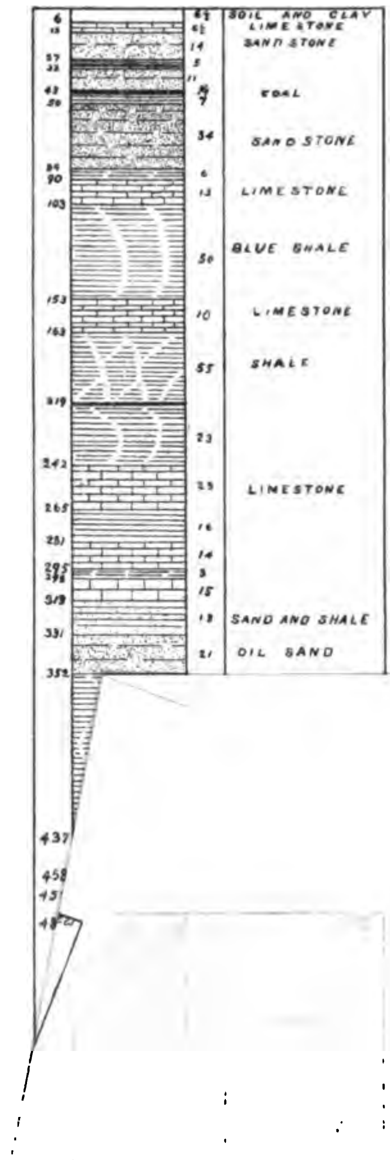
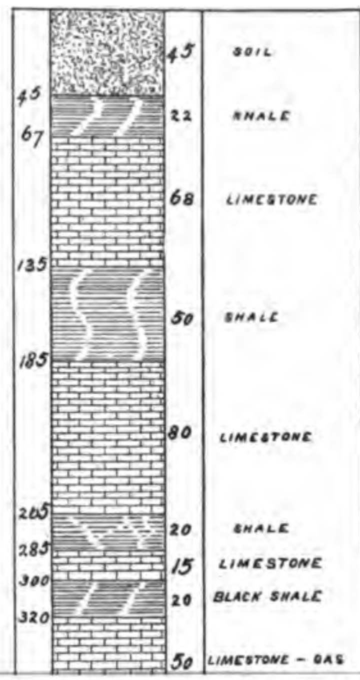


Figure 2.

NEODESHA WELL
Pierce Bro's Farm. G. & G.



Record of Humboldt Well No. 1, Allen County.

PLATE XXIII.

Located on Sec. 8, T. 26, R. 18. Reported by Guffey & Galey.

	MATERIAL.	Thickness of Strata.	Depth to Bottom of Strata.
1	Soil	22 feet	22 feet.
2	Gravel and Sand	8 "	30 "
3	Limestone	40 "	70 "
4	Black Slate Shale	25 "	95 "
5	Limestone	40 "	135 "
6	Slate Shale — Water	10 "	145 "
7	Limestone	30 "	175 "
8	Slate Shale and Shells	35 "	210 "
9	Shale — Water	8 "	218 "
10	Limestone	10 "	228 "
11	Slate Shale	3 "	231 "
12	Limestone	17 "	248 "
13	Slate Shale	5 "	253 "
14	Limestone	20 "	273 "
15	Slate Shale	172 "	445 "
16	Shells, broken	15 "	460 "
17	Limestone	10 "	470 "
18	Slate Shale	65 "	535 "
19	Limestone	40 "	575 "
20	Slate Shale	40 "	615 "
21	Limestone	20 "	635 "
22	Shale — Water	10 "	645 "
23	White Slate Shale	30 "	675 "
24	Black Slate Shale	70 "	745 "
25	White Slate Shale	15 "	760 "
26	Black Slate Shale	36 "	796 "
27	Sandstone	2 "	798 "
28	Black Slate Shale	96 "	894 "
29	Sandstone	5 "	899 "
30	Slate Shale	46 "	945 "
31	Sandstone — Salt water	25 "	970 "

Record of Well at La Harpe, Allen County.

PLATE XXIII.

Located on the S. E. corner of Sec. 18, T. 24 South, R. 20 East. Reported by L. C. Beattie, Manager of the Palmer Oil Company.

	MATERIAL.	Thickness of Strata.	Depth to Bottom of Strata.
1	Soil and Gravel	14 feet	14 feet.
2	Limestone	35 "	49 "
3	Slate and Soapstone Shales	25 "	74 "
4	White Limestone	10 "	84 "
5	Slate Shale	40 "	124 "
6	Gray Sandstone	15 "	139 "
7	Green Limestone	25 "	164 "
8	White Limestone	20 "	184 "
9	Black Limestone	10 "	194 "
10	Black Slate Shale	10 "	204 "
11	Red Flint	3 "	207 "
12	Slate Shale	8 "	215 "
13	Limestone and Red Flint	15 "	230 "
14	Black Slate Shale	5 "	235 "
15	Limestone	5 "	240 "
16	Slate Shale	5 "	245 "
17	Limestone, dark	10 "	255 "
18	Limestone, shelly	20 "	275 "
19	Brown Slate Shale	2 "	277 "
20	Gray Sandstone	20 "	297 "
21	Reddish Slate Shale	80 "	377 "
22	Gray Sandstone	18 "	395 "
23	Slate Shale	33 "	428 "
24	Black Limestone	16 "	444 "
25	Shelly Limestone	20 "	464 "
26	Dark Slate Shale	16 "	480 "
27	Gray Sandstone	25 "	505 "
28	Slate Shale	8 "	513 "
29	Sandstone	15 "	528 "
30	Slate Shale	15 "	543 "
31	Dark Slate	5 "	548 "
32	White Limestone, shelly	12 "	560 "
33	Dark Limestone and Red Flint	15 "	575 "
34	Slate Shale	5 "	580 "
35	Black Limestone, hard	8 "	588 "
36	Black Shale — trace of Gas	20 "	608 "
37	Limestone	8 "	618 "
38	Limestone, black — oily smell	4 "	620 "
39	Jet black Slate Shale	5 "	625 "
40	Dark Limestone	12 "	637 "
41	Gray Slate Shale	5 "	642 "
42	Gray Sandstone	8 "	650 "
43	Gray Slate Shale	8 "	658 "
44	Dark Slate Shale	6 "	664 "
45	Red Flint and Limestone	3 "	667 "
46	Black Shelly Sandstone	10 "	677 "
47	Dark Slate Shale	26 "	703 "
48	Slate Shale, changeable; light, dark, green, black	192 "	895 "
49	Sand Shales; some clear Sand	12 "	907 "
50	Black Slate Shale	61 "	968 "
51	Flint and Quartz	8 "	976 "

Figure 1.

HUMBOLDT WELL
Sec. 8, T. 26, R. 18.

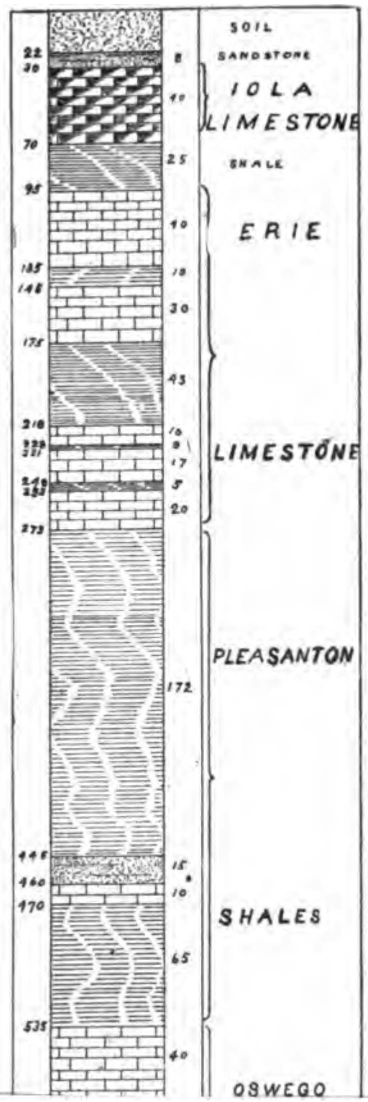
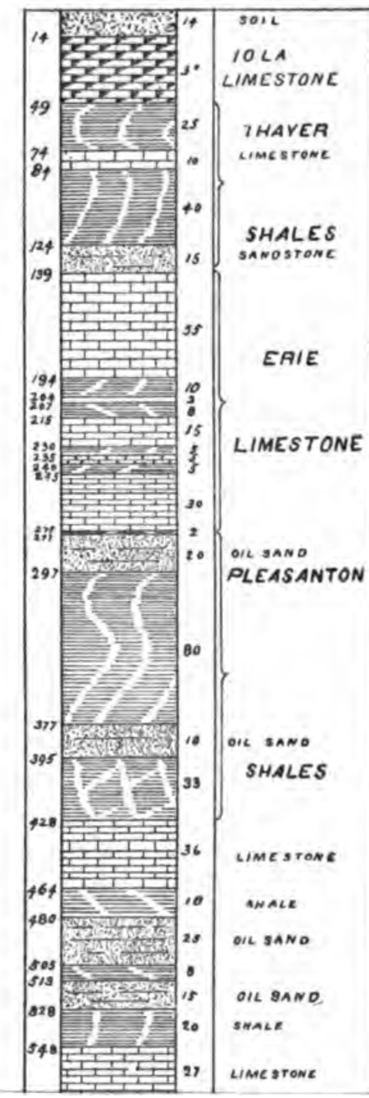


Figure 2.

LA HARPE WELL
Sec. 18, T. 24, R. 20. P.O. Co.



Record of the Nichols Well, Okmulgee County

Plate XXIV

Reported by Coffey & Gates

Depth to bottom of stratum	Thickness	Strata
[illegible]	[illegible]	[illegible]

Record of Frederick Well, Wilson County

Plate XLV

Completed Aug. 28, 1909

Reported by Coffey & Gates

Depth to bottom of stratum	Thickness of strata	Strata
[illegible]	[illegible]	[illegible]

Record of the Niotaze Well, Chautauqua County.

PLATE XXIV.

Located on Sec. 17, T. 34, R. 13.   Completed Nov. 3, 1894.
Reported by Guffey & Galey.

	MATERIAL.	Thickness of Strata.	Depth to Bottom of Strata.
1	Soil	68 feet	68 feet.
2	Sandstone—Fresh water	17 "	80 "
3	Sandstone—Salt water	170 "	250 "
4	Sandstone— " "	90 "	340 "
5	Sandstone— " "	100 "	440 "
6	Sandstone— " "	110 "	550 "
7	Sandstone— " "	120 "	670 "
8	Slate Shale	130 "	800 "
9	Limestone	40 "	840 "
10	Slate Shale	40 "	880 "
11	Limestone	43 "	923 "
12	Sandstone	52 "	975 "
13	Slate Shale	65 "	1,040 "
14	Limestone	30 "	1,070 "
15	Slate Shale	65 "	1,135 "
16	Limestone	23 "	1,158 "

Record of Fredonia Well, Wilson County.

PLATE XXIV.

Located on Sec. 11, T. 29, R. 14.   Completed Aug. 18, 1894.
Reported by Guffey & Galey.

	MATERIAL.	Thickness of Stata.	Depth to Bottom of Strata.
1	Clay	30 feet	30 feet.
2	Limestone	110 "	140 "
3	Shale	121 "	261 "
4	Sandstone	25 "	286 "
5	Shale	10 "	296 "
6	Limestone	15 "	311 "
7	Shale	22 "	333 "
8	Limestone	172 "	505 "
9	Shale	20 "	525 "
10	Limestone	35 "	560 "
11	Shale	82 "	642 "
12	Limestone	10 "	652 "
13	Shale	5 "	657 "
14	Sandstone	15 "	672 "
15	Shale	10 "	682 "
16	Sandstone	41 "	723 "
17	Shale	47 "	760 "
18	Limestone	25 "	785 "
19	Black Slate Shale	10 "	795 "
20	Sandstone	5 "	800 "
21	Shale	15 "	815 "
22	Limestone	28 "	843 "
23	Black Slate Shale	10 "	853 "
24	Limestone	5 "	858 "
25	Shale	143 "	1,001 "
26	Black Sandstone	10 "	1,011 "
27	Shale	54 "	1,065 "
28	Black Sandstone	75 "	1,140 "
29	Shale	30 "	1,170 "
30	Flint	54 "	1,224 "

Figure 1.

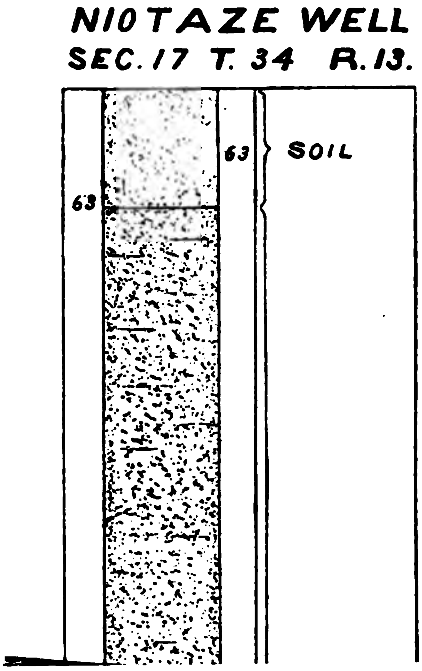
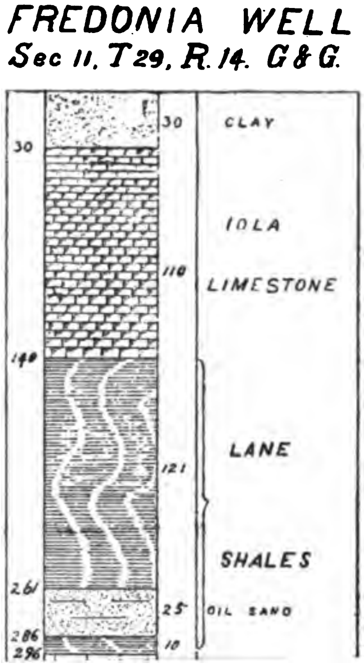


Figure 2.



UNIT WELL

SAND-

STONE

SHALE

Record of Fall River Well.

PLATE XXV.

Drilled on the south side of Fall River, in Liberty township, Elk County, Kansas. Located on the northeast quarter of the northeast quarter of Section 21, Township 28, Range 13. Completed August 21, 1895. Record furnished by Guffey & Galey.

	MATERIAL.	Thickness of Strata.	Depth to Bottom of Strata.
1	Soft Surface to Gravel	43 feet	43 feet.
2	Gravel	4 "	47 "
3	Black Slate Shale	4 "	51 "
4	Hard Mill Limestone	5 "	56 "
5	Slate Shale	12 "	68 "
6	Limestone, very hard	8 "	76 "
7	Slate Shale	173 "	249 "
8	Limestone	70 "	319 "
9	Slate Shale	20 "	339 "
10	Limestone	55 "	394 "
11	Slate Shale	96 "	490 "
12	Limestone	20 "	510 "
13	White Sandstone, strong flow of water, (cased at 662 feet)	20 "	530 "
14	Limestone, a little water	315 "	845 "
15	Slate, (caved badly)	60 "	905 "
16	Sandy Limestone	30 "	935 "
17	Slate Shale, (caved)	35 "	970 "
18	Water Sand, (cased at 1000 feet)	25 "	995 "
19	Slate Shale	7 "	1,002 "
20	Limestone	30 "	1,032 "
21	Slate and Caving Limestone	72 "	1,110 "
22	Sandstone	10 "	1,120 "
23	Slate Shale	130 "	1,250 "
24	Black soft Sandstone	8 "	1,258 "
25	Sandstone	22 "	1,280 "
26	Slate Shale	40 "	1,320 "
27	Limestone, mixed with Shells and Sand	85 "	1,405 "
28	Flint, with water	75 "	1,480 "

Record of a Well at Chanute, Neosho County.

PLATE XXV.

Ten feet lower than Santa Fe track at water station. Completed May 18, 1894. Located on Section 16, Township 27, Range 18. Reported by Guffey & Galey.

	MATERIAL.	Thickness of Strata.	Depth to Bottom of Strata.
1	Sandy Soil	4 feet	4 feet.
2	Loose Soil	15 "	19 "
3	Quicksand and Gravel	5 "	24 "
4	Soapstone Shale	8 "	32 "
5	Limestone and Shale	98 "	130 "
6	Black Slate Shale—Water	10 "	140 "
7	Limestone	30 "	170 "
8	Shale	2 "	172 "
9	Limestone	8 "	180 "
10	Shale, Sandstone and Slate	109 "	289 "
11	Limestone	5 "	294 "
12	Shale	20 "	314 "
13	Slate Shale	4 "	318 "
14	Limestone	10 "	328 "
15	Shale and Limestone	76 "	404 "
16	Blue Sandstone	8 "	412 "
17	Shale	5 "	431 "
18	Limestone	55 "	486 "
19	Black Slate Shale	2 "	488 "
20	Limestone	8 "	496 "
21	Blue Shale	26 "	522 "
22	Limestone	18 "	540 "
23	Black Slate Shale	5 "	545 "
24	Limestone	4 "	549 "
25	Blue and Black Slate Shale	257 "	806 "
26	Black Sandstone	5 "	811 "
27	Gray Sandstone	10 "	821 "
28	White Sandstone —Salt Water	143 "	964 "
29	Black Shale	6 "	970 "
30	Limestone	12 "	982 "

Figure 1.

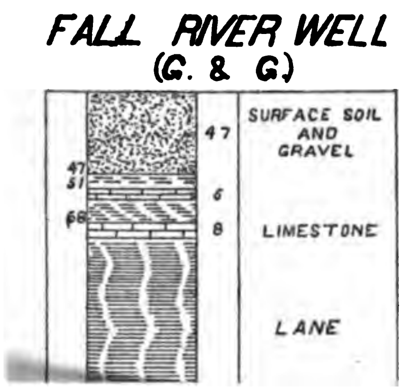
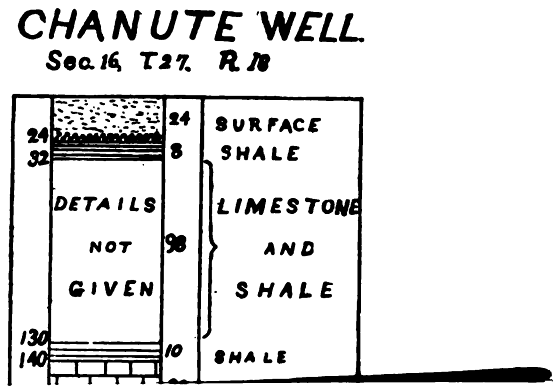
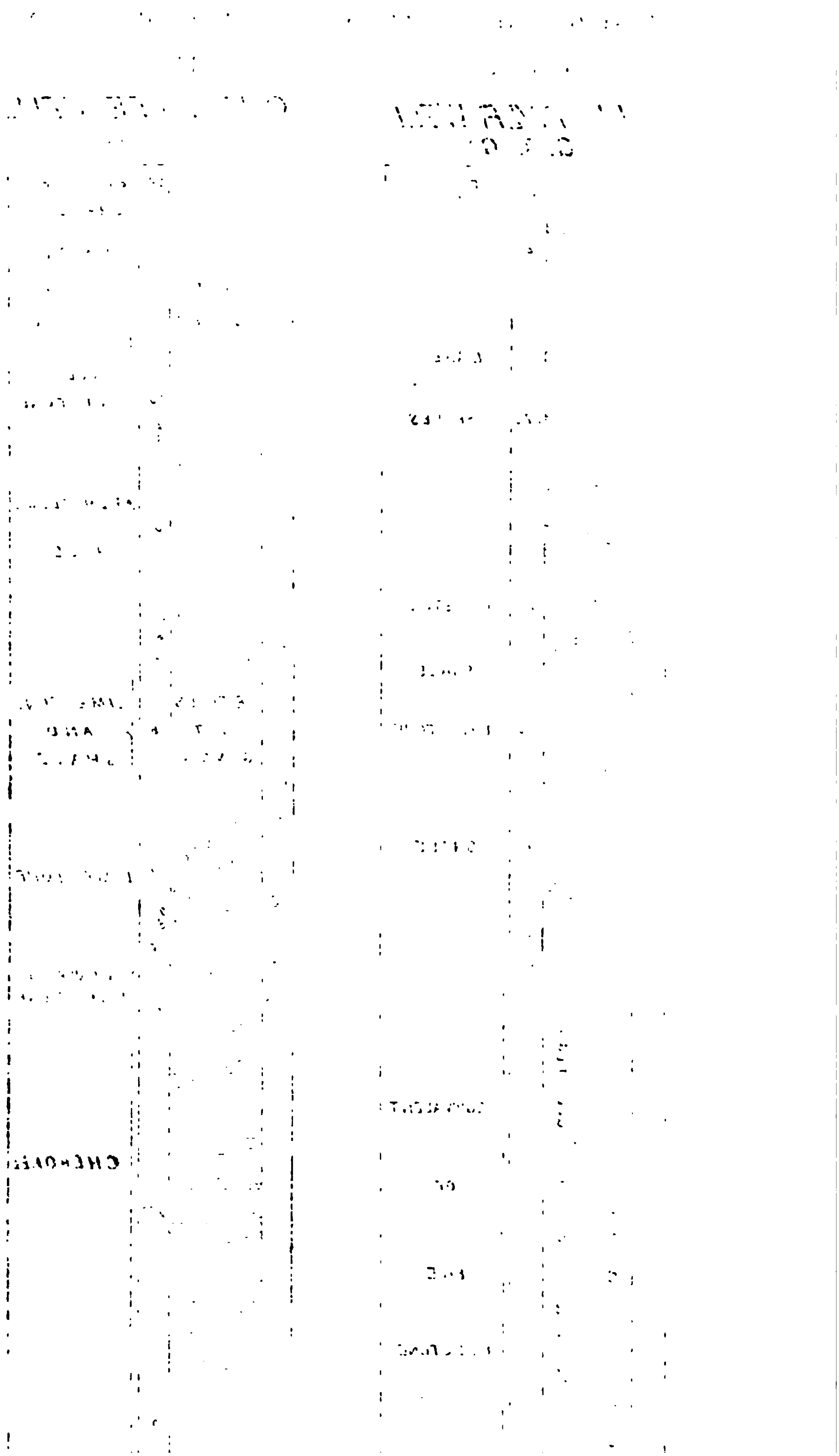


Figure 2.





Record of the Penitentiary Coal Shaft.

Plate XXVI.

Located at L[illegible]g, Leavenworth county. Published by Mr. Oscar Lamm. See Trans. Kans. Acad. Sci., Vol. XIV, p. 228, Topeka, 1896.

Depth to Bottom of Strata.	Thickness of Strata.	Strata.
[illegible]	[illegible]	[illegible]

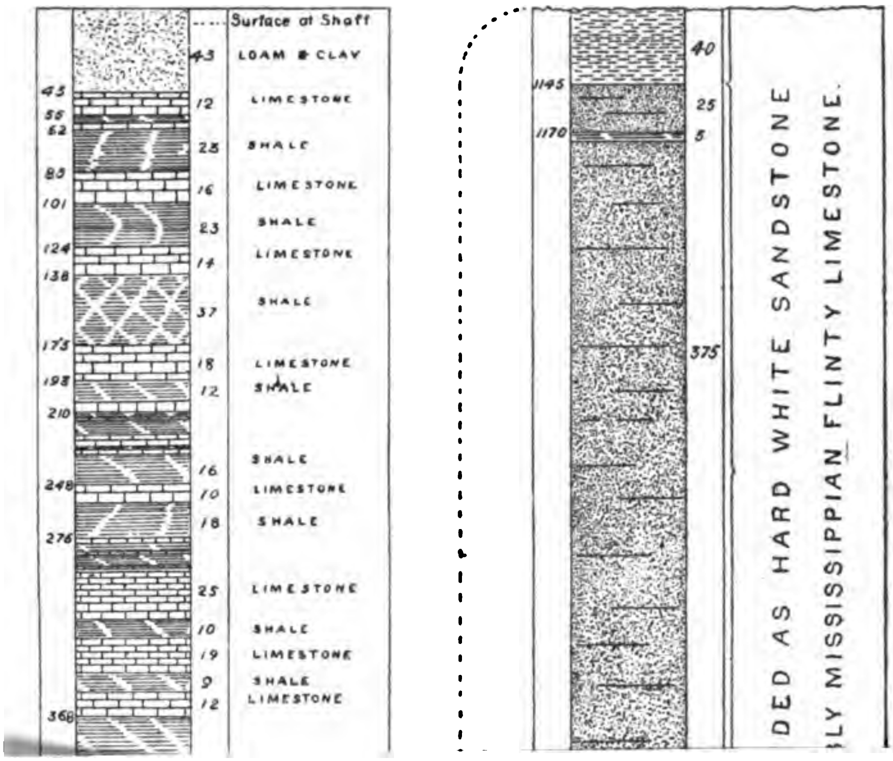
Record of the Penitentiary Coal Shaft.

PLATE XXVI.

Located at Lansing, Leavenworth county. Published by Mr. Oscar Lamm.
See Trans. Kans. Acad. Sci., Vol. XIV, p. 233, Topeka, 1896.

	MATERIAL.	Thickness of Strata.		Depth to Bottom of Strata.	
1	Surface Clay, bowlders, etc.	35 feet	5 inches.	35 feet	5 inches.
2	Limestone, gray	12 "		47 "	5 "
3	Shale, black	3 "	11 inches	51 "	4 "
4	Limestone, blue	2 "	5 "	53 "	9 "
5	Soapstone Shale, light drab.	23 "	6 "	77 "	3 "
6	Limestone, gray dark	15 "	8 "	92 "	11 "
7	Shale, green gray	23 "		115 "	11 "
8	Limestone, brown	6 "	8 inches	122 "	7 "
9	Limestone, gray	7 "	10 "	130 "	5 "
10	Soapstone Shale, light drab.	37 "		167 "	5 "
11	Limestone, brown	17 "	10 inches	185 "	3 "
12	Shale, black	11 "	8 "	196 "	11 "
13	Limestone, dark gray	4 "	10 "	201 "	9 "
14	Shale, dark gray	3 "	2 "	204 "	11 "
15	Limestone, brown	1 "	1 "	206 "	
16	Shale, gray purple	8 "		214 "	
17	Limestone, gray	6 "	5 inches	220 "	5 inches.
18	Shale, green	1 "	6 "	221 "	11 "
19	Limestone, gray	2 "	5 "	224 "	4 "
20	Shale, gray	15 "	6 "	239 "	10 "
21	Limestone drab	10 "	2 "	250 "	
22	Shale, gray	18 "	4 "	268 "	4 "
23	Limestone, gray	2 "	6 "	270 "	10 "
24	Shale, gray	4 "	3 "	275 "	1 "
25	Limestone, dark gray	1 "	11 "	277 "	
26	Shale, black	5 "	10 "	282 "	10 inches.
27	Limestone, light gray	1 "	7 "	284 "	5 "
28	Shale, gray	1 "	6 "	285 "	11 "
29	Limestone, gray	21 "		306 "	11 "
30	Limestone, black	4 "		310 "	11 "
31	Shale, black	10 "	1 inches	321 "	
32	Limestone, gray	18 "	8 "	339 "	8 "
33	Shale and Limestone, drab, etc.	9 "		348 "	8 "
34	Limestone, light gray	12 "	3 inches	360 "	11 "
35	Shale, gray, etc	142 "	8 "	503 "	7 "
36	Limestone, brown		6 "	504 "	1 "
37	Shale, drab	7 feet	10 "	511 "	11 "
38	COAL		2 "	512 "	1 "
39	Shale, drab	9 feet	2 "	521 "	3 "
40	Limestone, light brown	5 "		526 "	3 "
41	Shale, black	3 "	9 inches	530 "	
42	Limestone, gray	1 "		531 "	
43	Shale, black	1 "		532 "	
44	Limestone, gray	3 "	2 inches	535 "	2 inches.
45	Shale, black	7 "	5 "	542 "	7 "
46	Limestone, light gray	3 "	5 "	546 "	
47	Shale, black		6 "	546 "	6 "
48	Limestone, light gray	2 feet		548 "	6 "
49	Sandstone, brown gray	8 "	3 inches	556 "	9 "
50	Shale, black	12 "		568 "	9 "
51	Limestone, brown	3 "	3 inches	572 "	
52	Shale, black	2 "	6 "	574 "	6 "
53	COAL		8 "	575 "	2 "
54	Fire Clay		6 "	575 "	8 "
55	Sandstone, gray	4 feet		579 "	8 "
56	Shale, drab	2 "	2 inches	581 "	10 "
57	Shale, bituminous	1 "	8 "	583 "	6 "
58	Shale, buff	1 "	9 "	585 "	3 "
59	Limestone, light gray	4 "		589 "	3 "
60	Shale, drab purple	9 "	6 inches	598 "	9 "
61	Limestone, light gray	2 "	2 "	600 "	11 "
62	Shale, black	4 "	9 "	605 "	8 "
63	COAL		7 "	606 "	3 "
64	Fire Clay, drab	5 feet	1 "	611 "	4 "
65	Limestone, light gray	3 "	3 "	614 "	7 "
66	Shale, drab	2 "	3 "	616 "	10 "
67	Limestone, light gray	1 "	10 "	618 "	8 "
68	Shale, drab		4 "	619 "	
69	Limestone, light gray	2 feet	7 "	621 "	7 "
70	Shale, black	2 "	4 "	623 "	11 "
71	Fire Clay, dark	3 "	7 "	627 "	6 "
72	Shale, light sandy	24 "		651 "	6 "
73	Shale, dark drab	8 "		659 "	6 "
74	Limestone, dark gray		6 inches	660 "	
75	Shale, drab	10 feet	1 "	670 "	1 "
76	COAL		10 "	670 "	11 "
77	Fire Clay, drab		2 "	671 "	1 "
78	Sandstone, black	6 feet		677 "	1 "
79	Slate, drab, etc	7 "	1 inches	684 "	2 "
80	COAL		2 "	684 "	4 "
81	Fire Clay and Shale	1 feet	4 "	685 "	8 "
82	Shale, dark		3 "	688 "	8 "
83	Slate, drab and black	23 feet	4 "	712 "	
84	COAL	1 "	9 "	713 "	9 "

LEAVENWORTH CITY WELL AND LANSING COAL SHAFT COMBINED



5	Dark Shale	2 "	37 "
6	Gray Limestone	3 "	40 "
7	Light Shale	10 "	50 "
8	Shells of Limestone	3 "	53 "
9	Soft Shale	7 "	60 "
10	Hard Limestone	5 "	65 "
11	Soft Shale	10 "	75 "
12	Limestone	4 "	79 "
13	Sandy Shale	34 "	113 "
14	Limestone	4 "	117 "
15	Shale	1 "	118 "
16	Limestone	7 "	125 "
17	Shale	13 "	138 "
18	Limestone	20 "	158 "
19	Black Slate Shale	5 "	163 "
20	Limestone	1 "	164 "
21	Soft Soapstone Shale	10 "	174 "
22	Magnesia Limestone	10 "	184 "
23	Sandy Shale	20 "	204 "
24	Shale, trace of COAL	10 "	214 "
25	Shale	10 "	224 "
26	Sandstone — salt water	15 "	239 "
27	Shale	3 "	242 "
28	Sandstone	12 "	254 "
29	Blue Shale	37 "	291 "
30	Sandstone	12 "	303 "
31	Shale	92 "	395 "
32	Sandstone	105 "	500 "
33	Soft Shale	7 "	507 "
34	Limestone	93 "	600 "
35	Shale	70 "	670 "
36	Limestone	57 "	727 "
37	Shale	11 "	738 "
38	Sandstone	82 "	820 "
39	Limestone	10 "	830 "
40	Black Slate Shale	5 "	835 "
41	Limestone — salt water	17 "	852 "
42	Shale	6 "	858 "
43	Limestone	9 "	867 "
44	Slate Shale	118 "	985 "
45	Sandstone	20 "	1,005 "
46	Soapstone Shale	2 "	1,007 "

Record of a Deep Well at Eureka, Greenwood County.

PLATE XXVII.

Bored by Churn Drill. Reported by L. C. Wooster. Completed October 6, 1897.

	MATERIAL.	Thickness of Strata.		Depth to Bottom of Strata.	
1	Clay and Gravel	15 feet		15 feet.	
2	Limestone	2 "		17 "	
3	Shale	2 "	8 inches.	19 "	8 inches.
4	COAL		4 "	20 "	
5	Limestone	3 feet		23 "	
6	Shale	76 "		99 "	
7	COAL		8 inches	99 "	8 inches.
8	Limestone	45 feet	2 "	144 "	10 "
9	Shale	10 "	8 "	155 "	6 "
10	Arenaceous Limestone	6 "	8 "	162 "	2 "
11	Shale	20 "		182 "	2 "
12	Limestone	6 "	7 inches.	188 "	9 "
13	Black Slate Shale	3 "		191 "	9 "
14	Limestone	1 "	9 inches.	193 "	6 "
15	Shale	5 "	10 "	199 "	4 "
16	Red Clay	28 "		227 "	4 "
17	Limestone	1 "	4 inches.	228 "	8 "
18	Shale	9 "	4 "	238 "	
19	Limestone	1 "	4 "	239 "	4 "
20	Shale	5 "	3 "	244 "	7 "
21	Limestone, pyritiferous	9 "		253 "	7 "
22	Shale	12 "	10 inches.	266 "	5 "
23	Limestone	2 "		268 "	5 "
24	Limestone, "magnesia"	9 "	10 inches.	278 "	3 "
25	Limestone	5 "	6 "	283 "	9 "
26	Black Slate Shale	2 "	9 "	286 "	6 "
27	Limestone		8 "	287 "	2 "
28	Shale	43 feet	8 "	330 "	10 "
29	Limestone	28 "	3 "	359 "	1 "
30	Slate Shale	9 "		368 "	1 "
31	Flint	4 "	8 inches.	372 "	9 "
32	Limestone	10 "		382 "	9 "
33	Shale	23 "	7 inches.	406 "	4 "
34	Limestone	12 "	4 "	418 "	8 "
35	Shale	8 "	8 "	426 "	4 "
36	Sandstone	74 "	9 "	501 "	1 "
37	Limestone	1 "	1 "	502 "	2 "

Figure 1.

Figure 2.

unty.

6, 1897

Bottom
ts.

inches.

inches.

Record of a Deep Well at Emporia, Lyon County.

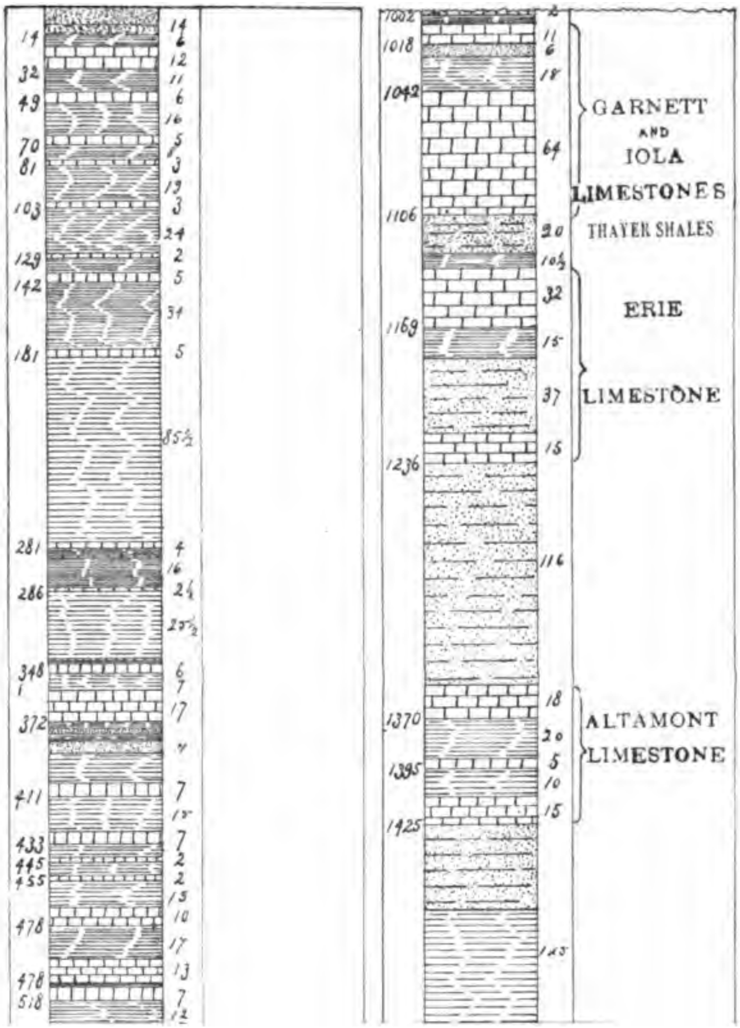
Plate XXVIII.

Elevation of Emporia: 1132 feet above Mean Tide.

Reported by L. C. Wooster.

	MATERIAL.	Thickness of Strata.	Depth to Bottom of Strata.
1	Black Soil	9 feet	9 feet
2	Blue Clay	5 "	14 "
3	Soapstone Shale	6 "	20 "
4	Limestone	2 " 6 inches	22 " 6 inches.
5	Cherty Limestone	9 " 6 "	32 "
6	Soapstone Shale	11 "	43 "
7	Limestone	6 "	49 "
8	Blue Soapstone Shale	16 "	65 "
9	Gray Limestone	5 "	70 "
10	Blue Soapstone Shale	8 "	78 "
11	Gray Limestone	3 "	81 "
12	Blue Soapstone Shale	19 "	100 "
13	Magnesia Limestone	3 "	103 "
14	Blue Shale	4 "	107 "

EMPORIA WELL.



Record of a Deep Well at Toronto, Woodson County.

PLATE XXIX.

Drilled by James Amm on the Robert Semple farm during the fall of 1896. Reported by Mr. Troxel.

	MATERIAL.	Thickness of Strata.	Depth to Bottom of Strata.
1	Soil and Clay	26 feet	26 feet.
2	Gravel	5 "	31 "
3	Soapstone Shale	79 "	110 "
4	Limestone	5 "	115 "
5	Soapstone Shale	6 "	121 "
6	Shale	30 "	151 "
7	Soft Slate Shale	104 "	255 "
8	Limestone	65 "	320 "
9	Shale	16 "	336 "
10	Brown Limestone	19 "	355 "
11	Limestone, Shale and Shells	53 "	408 "
12	Light Shale	90 "	498 "
13	Limestone, water	58 "	556 "
14	Shale	10 "	566 "
15	Limestone	15 "	581 "
16	Shale	27 "	608 "
17	Limestone	44 "	652 "
18	Brown Limestone, water	20 "	672 "
19	Dark Shale	3 "	675 "
20	Limestone	15 "	690 "
21	Shale	10 "	700 "
22	Limestone	24 "	724 "
23	Black Shale, water	5 "	729 "
24	Limestone	19 "	748 "
25	Gray Sandstone	15 "	763 "
26	Shale	3 "	766 "
27	Gray Sandstone	18 "	784 "
28	Blue Shale	85 "	869 "
29	Dark Shale	30 "	899 "
30	Light Shale	16 "	915 "
31	Limestone	18 "	933 "
32	Shale	72 "	1,005 "
33	Limestone	4 "	1,009 "
34	Shale	3 "	1,012 "
35	Limestone	14 "	1,026 "
36	Shale	6 "	1,032 "
37	Limestone	48 "	1,080 "
38	Dark Shale	24 "	1,104 "
39	Oil Sand	25 "	1,129 "
40	Shale	11 "	1,140 "
41	Shale	110 "	1,250 "
42	Soft Sandstone	4 "	1,254 "
43	Shale	86 "	1,340 "
44	Soft Sandstone	7 "	1,347 "
45	Shale	83 "	1,430 "
46	Soft Sandstone	8 "	1,438 "
47	Shale	14 "	1,452 "

Record of a Deep Well at Howard, Elk County.

PLATE XXIX.

MATERIAL.	Thickness of Strata.	Depth to Bottom of Strata.

Figure 1.

TORONTO WELL.

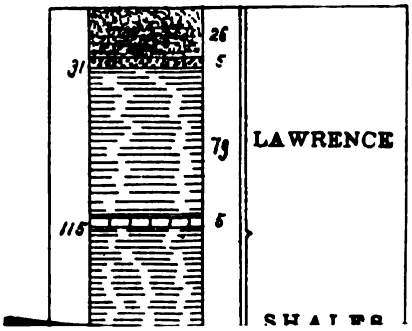
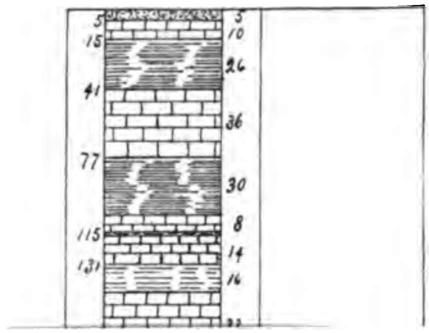


Figure 2.

HOWARD WELL.



Record of McFarland Well.

PLATE XXX.

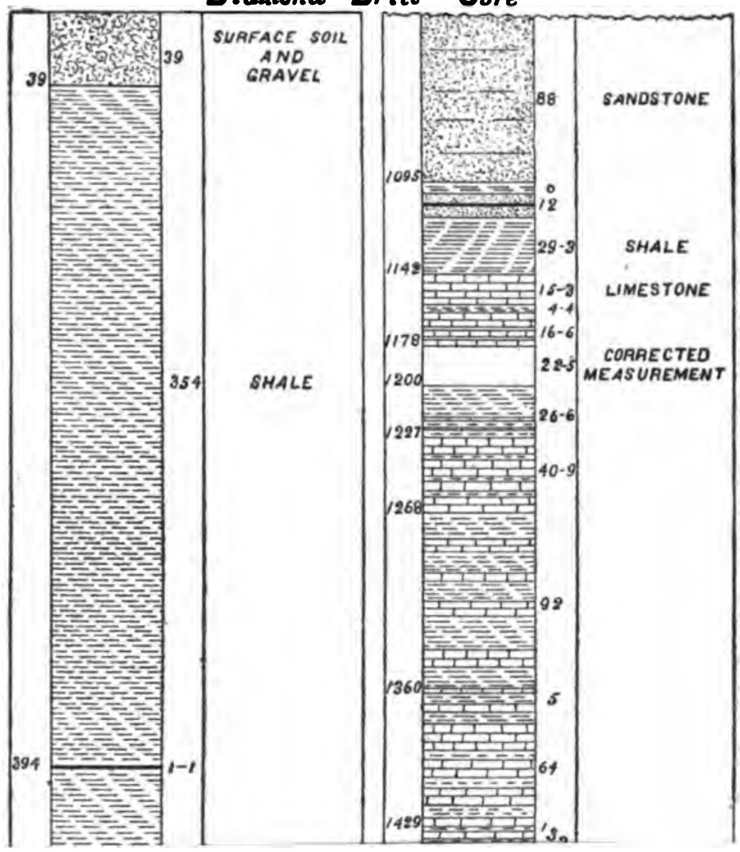
Record of McFarland Well.

PLATE XXX.

Diamond Drilled Prospect Well at McFarland, Wabaunsee County, Kansas. Drilled May to October, 1892. Record furnished by M. C. Bullock Manufacturing Company, Contractors.

	MATERIAL.	Thickness of Strata.	Depth to Bottom of Strata.
1	Loam	2 feet 6 inches	2 feet 6 inches.
2	Clay	31 " 6 "	34 "
3	Gravel	5 "	39 "
4	Shale, blue	76 "	115 "
5	Shale, black, trace of COAL	2 "	117 "
6	Shale, blue	42 " 1 inch	159 " 1 inches.
7	Shale, blue, Sand streaks	62 "	221 " 1 "
8	Shale, Clay, with occasionally Sandstone and Limestone	172 " 5 inches	393 " 6 "
9	COAL	6 "	394 "
10	Slate Shale	4 "	394 " 4 "
11	COAL	3 "	394 " 7 "
12	Shale, sandy	12 feet 6 "	407 " 1 "
13	Shale, Clay	14 "	421 " 1 "
14	Shale, sticky	9 " 5 inches	430 " 6 "
15	Shale, black	4 "	434 " 6 "
16	Shale, sandy	10 " 9 inches	445 " 3 "
17	Shale, Clay	21 " 1 "	466 " 4 "
18	Shale, dark Sand and Clay	34 " 1 "	500 " 5 "
19	Shale, Clay	34 " 7 "	535 "
20	COAL	8 "	535 " 8 "
21	Shale, Clay and Sandstone streaks	46 feet	581 " 8 "
22	Shale, soft Clay	7 " 10 inches	589 " 6 "
23	Shale, blue Clay with some Lime	12 " 8 "	606 " 2 "
24	Shale	2 " 10 "	609 "
25	Limestone	5 "	614 "
[illegible]	[illegible]	9 " 9 inches	[illegible]

McFARLAND WELL
Diamond Drill Core



McFARLAND WELL